Automatic Weather Station
MAWS101 & MAWS201

USER'S GUIDE

M210243en-A
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VAISALA

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CHAPTER 1

GENERAL INFORMATION

About This Manual

This manual provides information for installing, operating and maintaining MAWS101 and MAWS201 Automatic Weather Stations equipped with meteorological sensors. This manual consists of the following chapters:

- Chapter 1, General Information, provides important safety, revision history, contact, and warranty information for the product.
- Chapter 2, Product Overview, introduces the MAWS Automatic Weather Station features, accessories, sensors, and the product nomenclature.
- Chapter 3, Installation, describes how to mechanically put together a MAWS weather station that is mounted to a portable mast or to a pole mast.
- Chapter 4, Operation, provides the instructions for taking MAWS Automatic Weather Station into use when all the equipment has been assembled and installed.
- Chapter 5, Maintenance, provides information that is needed in the basic maintenance of MAWS.
- Chapter 6, Troubleshooting, consists of some common MAWS problems, their probable causes, and remedies.
- Chapter 7, Technical Data, provides the technical data of MAWS and its sensors.
- Appendix A, Glossary

Safety

General Safety Considerations

Throughout the manual, important safety considerations are highlighted as follows:

WARNING	Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.

CAUTION	Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.

NOTE	Note highlights important information on using the product.

Product Related Safety Precautions

MAWS has been tested for safety and approved as shipped from the factory. The following safety precautions are not related to any specific procedures and therefore do not appear elsewhere in this manual. They are recommended precautions that personnel must understand and apply during different phases of operation and maintenance.

WARNING	Keep away from live circuits. Operating personnel must observe safety regulations at all times. Component replacement or internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist for some time even with the power cable disconnected. To avoid injuries, disconnect power and discharge circuits before touching them.

WARNING Do not service alone. Under no circumstances should any person reach into parts and assemblies that are mains powered and alive, for the purpose of servicing, except in the presence of someone who is capable of rendering aid.

WARNING Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

WARNING Do not service a live system outdoors. Do not open units outdoors when the enclosure contains line voltage levels.

WARNING Do not operate in an explosive atmosphere, for example, when flammable gases or fumes are present. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

WARNING Do not substitute parts or modify the instrument. Because of the danger of introducing additional hazards, do not install unsuitable parts in the instrument. Contact Vaisala or its authorized representative for repairs to ensure that safety features are maintained.

WARNING Be careful when erecting the mast. See that there are no power lines or other obstacles above the mast.

WARNING Secure the mast properly to prevent it from falling. Tighten all the adjustment screws securely.

CAUTION	Do not make changes to the wiring. Incorrect wiring can damage the device and prevent it from operating correctly.

CAUTION	Be careful when moving the mast. To prevent damage to the sensors, remove them (and the sensor arms) before moving the station.

NOTE	When disposing of old batteries, be sure to do so in accordance with all regulations applicable in your area.

ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects inside the equipment housing.

To make sure you are not delivering high static voltages yourself:

- Handle ESD sensitive components on a properly grounded and protected ESD workbench. When this is not possible, ground yourself to the equipment chassis before touching the boards. Ground yourself with a wrist strap and a resistive connection cord. When neither of the above is possible, touch a conductive part of the equipment chassis with your other hand before touching the boards.
- Always hold the boards by the edges and avoid touching the component contacts.

Version Information

Table 1 Manual Revisions

Manual Code	Description
U328en-1.1	Applicable to software version 0.80.07
U328en-1.2	Applicable to software versions from 0.807 to 0.903
U328en-1.3	Applicable to software versions from 0.904 to 1.0
U328en-1.4	Case specific manual
U328en-1.5	Applicable to software versions prior to 3.00.
U328en-1.6	Applicable to software versions prior to 3.00.
M210243en-A	This manual. Applicable from software version 3.00

Related Manuals

Table 2 Related Manuals

Manual Code	Manual Name
M010069en	YourVIEW Weather Display for MAWS- User's Guide
M010077en	MAWS301 - User's Guide
M010114en	MAWS301 - Installation Manual
M010141en	MAWS Lizard Setup Software - User's Guide
M010120en	Connecting DD50 and WD30 Displays via Radio Modem to MAWS - Technical Reference
M210222en	Using WD30(tu) and WD20 with MAWS - Technical Reference
M210223en	Using DD50 with MAWS - Technical Reference
N257en	MAWS Software loading - Technical Notice

Warranty

Vaisala hereby represents and warrants all Products manufactured by Vaisala and sold hereunder to be free from defects in workmanship or material during a period of twelve (12) months from the date of delivery save for products for which a special warranty is given. If any Product proves however to be defective in workmanship or material within the period herein provided Vaisala undertakes to the exclusion of any other remedy to repair or at its own option replace the defective Product or part thereof free of charge and otherwise on the same conditions as for the original Product or part without extension to original warranty time. Defective parts replaced in accordance with this clause shall be placed at the disposal of Vaisala.

Vaisala also warrants the quality of all repair and service works performed by its employees to products sold by it. In case the repair or service works should appear inadequate or faulty and should this cause malfunction or nonfunction of the product to which the service was performed Vaisala shall at its free option either repair or have repaired or replace the product in question. The working hours used by employees of Vaisala for such repair or replacement shall be free of charge to the client. This service warranty shall be valid for a period of six (6) months from the date the service measures were completed.

This warranty is however subject to following conditions:

a) A substantiated written claim as to any alleged defects shall have been received by Vaisala within thirty (30) days after the defect or fault became known or occurred, and

b) The allegedly defective Product or part shall, should Vaisala so require, be sent to the works of Vaisala or to such other place as Vaisala may indicate in writing, freight and insurance prepaid and properly packed and labeled, unless Vaisala agrees to inspect and repair the Product or replace it on site.

This warranty does not however apply when the defect has been caused through

a) normal wear and tear or accident;

b) misuse or other unsuitable or unauthorized use of the Product or negligence or error in storing, maintaining or in handling the Product or any equipment thereof;

c) wrong installation or assembly or failure to service the Product or otherwise follow Vaisala's service instructions including any repairs or installation or assembly or service made by unauthorized personnel not approved by Vaisala or replacements with parts not manufactured or supplied by Vaisala;

d) modifications or changes of the Product as well as any adding to it without Vaisala's prior authorization;

e) other factors depending on the Customer or a third party.

Notwithstanding the aforesaid Vaisala's liability under this clause shall not apply to any defects arising out of materials, designs or instructions provided by the Customer.

This warranty is expressly in lieu of and excludes all other conditions, warranties and liabilities, express or implied, whether under law, statute or otherwise, including without limitation ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE and all other obligations and liabilities of Vaisala or its representatives with respect to any defect or deficiency applicable to or resulting directly or indirectly from the Products supplied hereunder, which obligations and liabilities are hereby expressly cancelled and waived. Vaisala's liability shall under no circumstances exceed the invoice price of any Product for which a warranty claim is made, nor shall Vaisala in any circumstances be liable for lost profits or other consequential loss whether direct or indirect or for special damages.

CHAPTER 2

PRODUCT OVERVIEW

This chapter introduces the MAWS Automatic Weather Station features, accessories, sensors, and the product nomenclature.

Introduction to MAWS

MAWS is a compact weather station that can be used either with a portable tripod (MAWS201) or with pole masts of different heights in fixed installations (MAWS101 and MAWS301). The weather station comes with a set of sensors, that measure certain meteorological quantities and that have been especially selected for use with MAWS.

MAWS101 Mini AWS

MAWS101 can be installed on a pole mast. The logger enclosure is then attached to a short support arm, which is secured around the mast with fixing clamps.

The maximum height of MAWS101 is 3 meters. Alternatively, the wind sensors can be installed up to 10 meters away from the electronics. With an extension cable, this distance can be extended further.

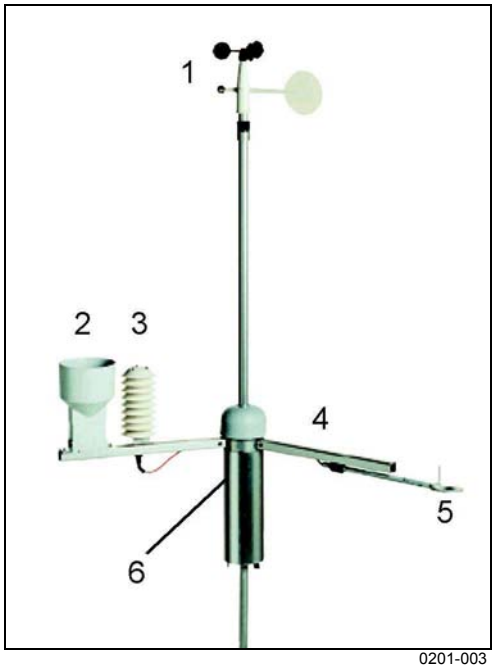

Figure 1 Components of MAWS101 Weather Station

The following numbers refer to Figure 1 above.

1 = QMW101 Wind Sensor with a fixing adapter and the 1-meter cable
2 = QMR101 Precipitation Sensor
3 = QMH101 Temperature and Humidity Probe with radiation shield
4 = QMA101 Sensor Arm
5 = QMN101 Net Radiation Sensor
6 = Tube, that includes the QML102 logger, QMB101 rechargeable internal battery, and optionally PMT16A Pressure Sensor

MAWS201 Mobile AWS

If you have purchased a portable MAWS Weather Station (MAWS201) with a basic sensor set, your station will typically consists of the components presented in Figure 2 on page 19.

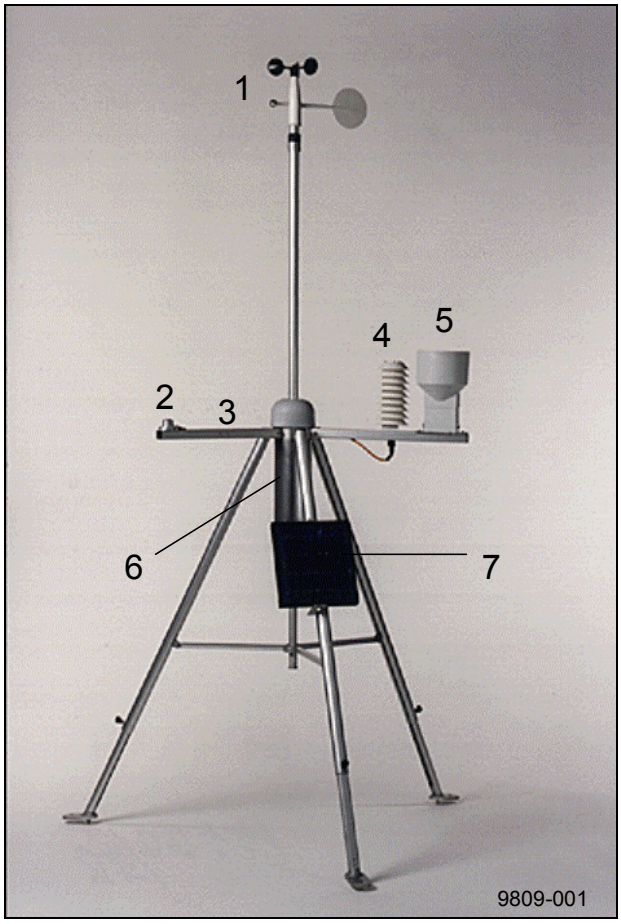

Figure 2 Components of MAWS201 Weather Station

The following numbers refer to Figure 2 above.

1 = QMW101 Wind Sensor with a fixing adapter and 1-meter cable
2 = QMS101 Solar Radiation Sensor
3 = QMA101 Sensor Arm
4 = QMH101 Temperature and Humidity Probe with radiation shield
5 = QMR101 Precipitation Sensor with cable
6 = Tube, that includes the QML102 logger, QMB101 rechargeable internal battery, and optionally PMT16A Pressure Sensor.
7 = Solar panel for generating current for recharging the internal battery.

In addition to the numbered items, the delivery contains the portable mast assembly consisting of a tripod with adjustable extension legs

attached to the logger housing. The tripod can be easily collapsed to fit in a carrying bag.

NOTE The appearance of the solar panel in your MAWS may differ from the one in the figures.

Product Nomenclature

The following five tables provide the equipment nomenclature information on the MAWS101 and MAWS201.

Table 3 MAWS Nomenclature (Basic Set)

Code	Common Name
MAWS Lizard	Setup software
MAWS Terminal	MAWS Terminal software
MAWS YourVIEW	Graphical Display Software (Basic version)
QMA101	Sensor arm
QMB101	Battery (internal rechargeable 6 V/1.2 Ah)
QMH101	Air temperature and relative humidity sensor
QML102	Logger (with 2 MB Flash memory)
QMW101	Combined wind direction and speed sensor with 1 m cable
QMW110	Same as QMW101 but with 10 m cable
DTR502	Radiation shield for QMH101
Tripod	3 m portable mast with the enclosure, accessories and a sensor support arm for MAWS201

Table 4 MAWS Nomenclature (Sensor Options)

Code	Common Name
ML2x	Soil moisture sensor
PMT16A	Pressure sensor
QFM101	Fuel moisture sensor
QLW101	Leaf wetness sensor
QMN101	Net solar radiation sensor
QMR101	Rain gauge (on sensor arm)
QMR102	Rain gauge (stand-alone)
QMS101	Global solar radiation sensor (photodiode)
QMS102	Global solar radiation sensor (thermopile)
QMT103	Soil/water temperature sensor
QMT107	Soil temperature sensor
QMV101	Water level sensor
QMV102	Water level sensor

Table 5 MAWS Nomenclature (Communication Options)

Code	Common Name
DMX501	Modem module (fixed line)
DSI485A	RS-485 module (isolated)
DSI486	RS-485/RS-232/SDI-12 module (dual-isolated)
DSU232	RS-232 module (dual)
	SATELLINE 3AS Radio Modem

Table 6 Installation Accessories

Code	Common Name
DKP102	2-meter pole mast for MAWS101
DKP12	10-meter pole mast for MAWS110
QMA101	Sensor support arm

Table 7 MAWS Nomenclature (Optional Accessories)

Code	Common Name
MAWS YourVIEW with TCP/IP	Graphical Display Software with TCP/IP connection
QBR101	Battery regulator
QMC102	Memory Expansion Board
QMM110	Carry case (canvas bag for tripod, hard case for sensors)
QMM120	Carry case (hard case for tripod, hard case for sensors
QMP201C	Solar/Mains Power Supply
QMP213	Mains Power Supply
SOLAR6	6 W solar panel for MAWS201
SOLAR6-75	6 W solar panel with 6 m cable for MAWS101

MAWS Software

Operating Software

The embedded operating software runs in the QML102 AWS logger. Access to the operating software commands can be gained using the MAWS Terminal.

Lizard Setup Software

Lizard Setup Software is used to modify the software parameters and operation of the MAWS weather station. With the Lizard software you can create or modify a setup file that informs MAWS how to operate.

Creating a setup with Lizard Setup Software consists of three stages. First, you define an assembly for the MAWS weather station. Then you define the necessary measurements and the calculations derived from them. Finally, you define reports and log groups from the measurement results.

The setup file on your PC is finally generated, in other words, converted into a format that MAWS understands, and then transferred into MAWS and taken into use.

MAWS Terminal

MAWS Terminal is the terminal software for working with MAWS Automatic Weather Stations. MAWS stations measure weather data and store it in log files. With the MAWS terminal software, you can download these files to your PC and view them.

When you start using MAWS, the first thing you need to do is to define what weather parameters you want to measure and at what frequency. You can do this by uploading a configuration file from your PC to the MAWS.

MAWS Terminal is also used for setting the station specific parameters such as the station name, altitude, pressure sensor height, and sensor specific calibration coefficients. In addition, the date and time can be set using the easy-to-use **MAWS Station Settings** template.

After you have uploaded the configuration files to the MAWS, you can browse the MAWS weather data files by downloading them from the MAWS to your PC. You can browse them in MAWS Terminal or in other applications. You can define several download settings such as where you want to save the downloaded files and what operations the program performs automatically at each download.

QML102 AWS Logger

QML102 is a complete AWS logger designed on one printed board only. This board contains a 32 bit Motorola CPU for data processing and 10 differential (20 single ended) analog sensor inputs, that can also be used as digital inputs. Moreover, there are two frequency sensor interfaces, a 16 bit A/D converter, 1.7 Mbytes of secure Flash memory for data logging, as well as charger for the internal backup battery of 1.3 Ah/6V.

The board uses the latest SMD (Surface Mount Device) technology and is conformal coated for improved protection also in high humidity. Each sensor input has a varistor (VDR) protection against induced transients. The maintenance terminal connection (RS-232, COM0) has transzorb diodes in its inputs.

0105-001

Figure 3 QML102 Logger

In MAWS101 and MAWS201 the QML102 logger is located in the tube and is further encased to protect the circuit board and the battery. The cover of this protective housing can be removed for installation of the battery and for resetting the MAWS. See Figure 4 on page 24.

Optional modules under the housing include, for example, the Memory Expansion Board, various communication modules, and built-in pressure transducer.

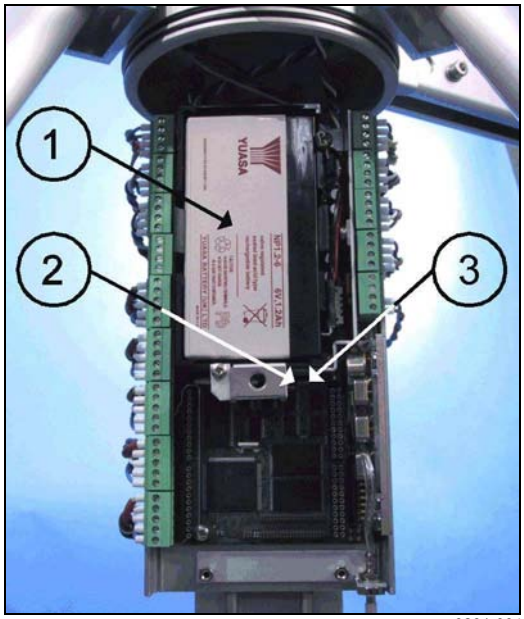

Figure 4 QML102 Logger without the Cover

The following numbers refer to Figure 4 above.

1 = Internal battery
2 = Reset button
3 = Status LED

Memory Expansion Board (Optional)

The QML102 logger can be equipped with QMC102 Memory Expansion Board. This module uses the standard Compact Flash memory cards for logging a large amount of data. Additionally, QMC102 contains 512 kB extra RAM memory, which may be needed in systems with the large configuration due to, for example, extensive statistical calculations or large set of sensors connected to MAWS.

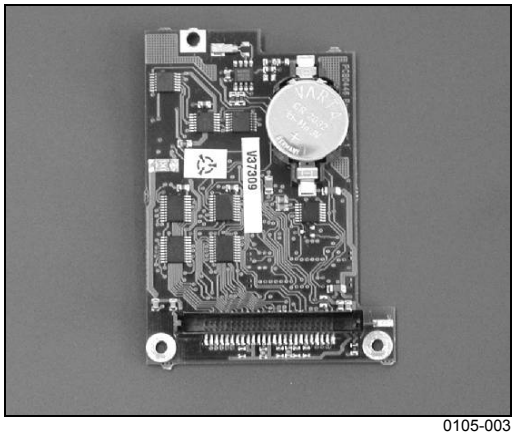

Figure 5 QMC102 Memory Expansion Board

The data is logged into the daily files making it easy to locate and download any particular data set for further analysis.

Currently there are cards available from 32 MB up to 280 MB. These cards can be read directly in the PC. Several different types of readers are commercially available: internal PCMCIA reader as well as external readers to be connected to USB or parallel port of a PC.

Figure 6 Compact Flash Memory Card Readers

Power Supplies

MAWS is a low-power system. The QML102 logger consumes only less than 10 mA from a 6 V battery. It can be powered using a solar panel or optionally in fixed installations using a 110/230 AC power supply. Also primary lithium or alkaline cells (6 ... 9 V) as well as external DC supply (8 ... 14 VDC recommended, 30 VDC max) alone can be used as the main power source for MAWS.

The power consumption of the complete MAWS system depends on the connected sensors, communication devices, and other options included in the delivery. For example, MAWS with basic set of 5 sensors, each having 10-minute measuring interval has an average power consumption of 10 mA.

Internal Battery

Normally, the internal battery QMB101 (1.2 Ah) is used as the primary power supply. The battery is recharged by the integral charger in the logger, accepting input from a solar panel, mains adapter, or an outdoors mains power supply. The QMB101 battery is placed on top of the circuit board, under the logger cover, see Figure 4 on page 24. Information about charging the battery can be found on page 169.

Solar Panels

SOLAR6 with MAWS201

MAWS201 is typically powered by SOLAR6, a 6 W solar panel, see Figure 7 below. The angle of the panel is adjustable.

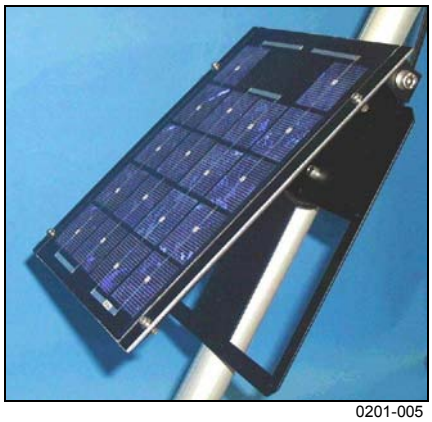

Figure 7 SOLAR6 Solar Panel

The SOLAR6 solar panel contains 18 high efficiency polycrystalline silicon cells in series optimized for the specific voltage demand. The solar panel’s cells are protected from dirt, moisture and impact by a tough fluoropolymer front film. The solar circuit is laminated using EVA between this film and adurable glass fibre board back which includes integral mounting holes.

SOLAR6-75 with MAWS101

MAWS101 can be powered by SOLAR6-75, a 6 W solar panel. SOLAR6-75 is especially designed for installation on a pole mast of 60-100 mm diameter. In addition to SOLAR6, the solar power package includes mast mounting accessories and a 6-meter cable with the connector. The angle of the panel is adjustable.

Mains Power Supplies

If AC power (230 or 115 VAC) is available on the installation site, and/or solar power is not feasible, an optional mains power supply can be used to charge the battery. For more information about connecting the power supplies, see the instructions on page 69.

A Wall Adapter

A usual wall adapter (110/230 VAC, output min. 12 V/500 mA) can be used when the distance to the MAWS station is less than 100 m, provided that the wall adapter can be installed indoors.

NOTE	When the power cable resistance exceeds 10 Ω, a capacitor (from 100 to 200 µF, 40 V) should be added between GND and +ExtDC pins. Make sure the polarity is correct.

QMP213

QMP213 is an outdoors power supply for installations where the AC power is available. The input may vary from 90 to 264 VAC with a frequency of 50 or 60 Hz. The power consumption is 1 A. The output provides 12 VDC, 2.5 A.

0201-006

Figure 8 QMP213 Mains Power Supply

QMP201C

QMP201C is a power supply for installations where more power and back-up capacity are needed. Additionally, QMPC201C can provide 12 V supply voltage required for example for optional radio modem set. QMP201C includes the following internal modules: the 12 W solar panel, battery regulator, mains power supply and 7 Ah back-up battery. The unit is easily mounted to the tripod's leg.

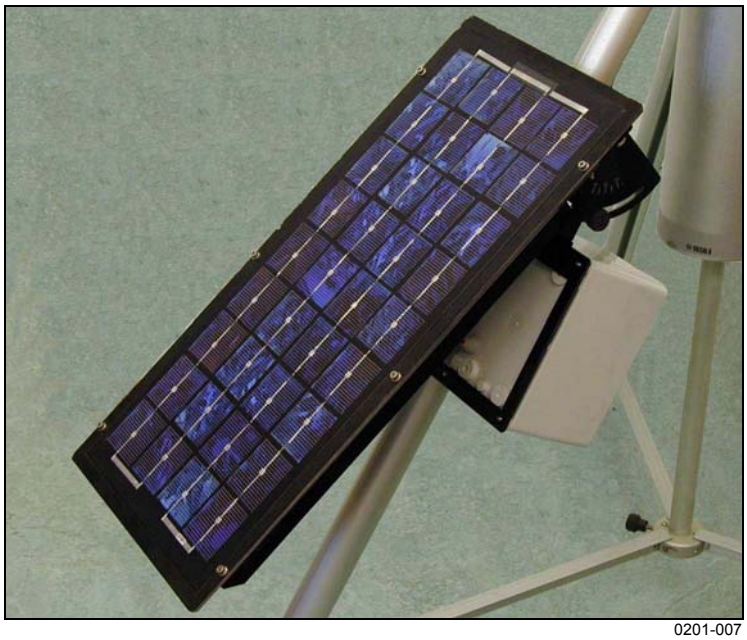

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Figure 9 QMP201C Solar/Mains Power Supply

QBR101 Battery Regulator

QBR101 Battery Regulator is a charging and supervising equipment for 12/24 Volts lead acid and nickel-cadmium batteries. QBR101 allows simultaneous input from both a solar panel and AC power.

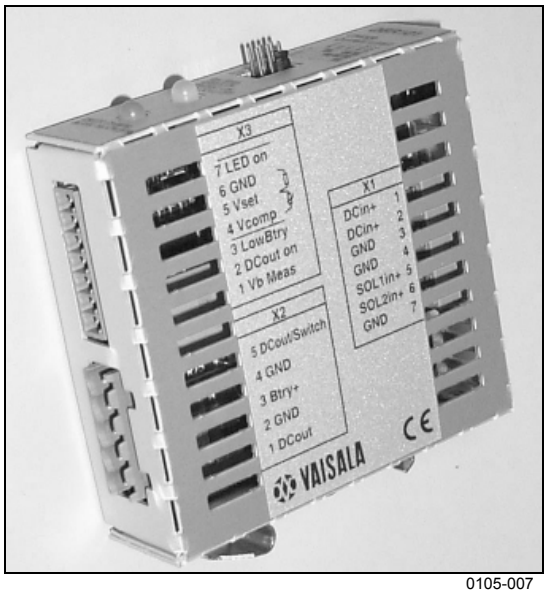

Figure 10 QBR101 Battery Regulator

The maximum charging current can be set by the internal jumper settings between 0.5 to 2.5 A being applicable for battery capacity of 4 to 72 Ah. The self-consumption from the battery is very low, less than 0.2 mA, which is required at installations at remote locations.

Also included are LED lamps that indicate the conditions. In order to maximize autonomy time, the lamps are activated only while pressing the ON button.

BWT15SX Mains Power Supply

The Mains power supply unit BWT15SX is a switching power supply, which operates from the universal AC input of 85 to 264 VAC and from 47 to 440 Hz. The output voltage is 15 VDC, which is used for powering the MAWS system, and as an input to the QBR101 battery regulator for charging the backup battery.

Sensors

Wind Sensor

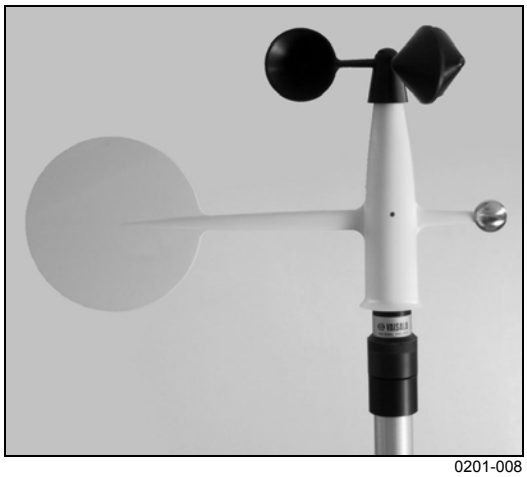

Figure 11 QMW101 Wind Sensor

QMW101 and QMW110 are compact sized wind sensors with the wind speed and direction sensors integrated into one unit. A single compact sensor is ideal for low-power applications. The rotating cup anemometer at the top of the unit provides isotropic and linear response to wind speed. The vane attached to the body of the unit provides fast response to wind direction. Direction is detected using an axial symmetric rotating potentiometer with two slides, thus providing a full range from 0 to 360°, while speed is converted into pulses using dual reed relay.

The cup wheel shape, dimensions and material have been carefully designed to achieve maximum quality of measurement. The conical cups have been tested to give linear response between wind speed and angular velocity of the cup wheel. The polyamide plastic reinforced with carbon fiber guarantees a rigid structure even at the highest wind speeds.

The balanced wind vane is integrated in the housing, underneath the cup wheel. The circular tail is located far enough from the body and the cup wheel to avoid turbulences due to these structures. The vane assembly is of PA (reinforced with glass fiber) providing durable and lightweight structure with fast response and low inertia.

Air Temperature and Relative Humidity Sensor

Figure 12 QMH101 Temperature and Relative Humidity Sensor

The QMH101 Relative Humidity and Temperature Sensor is based on Vaisala's field-proven HMP45D probe and comes with a special cable and connector. For humidity measurements, the HUMICAP sensor is highly accurate and offers excellent long-term stability in a wide range of environments. Temperature measurements are taken by an accurate Pt-100 IEC751, 1/3 Class B. Field calibration is easy with one or two references. The replacement is simple; the probe head containing the electronics can be quickly removed from the probe body, while a replacement is installed and the measurement continues. Meanwhile the other probe head is calibrated.

The probe is installed in a naturally aspirated shield made of injection moulded UV stabilized plastic. The shield has multiplate design providing the necessary shielding from solar radiation and precipitation.

Pressure Sensor

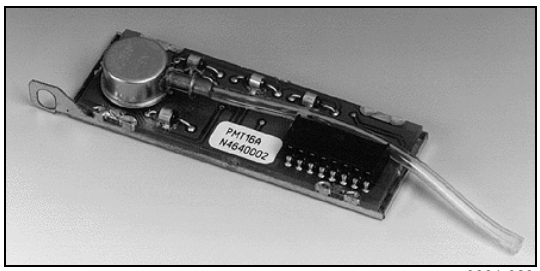

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Figure 13 PMT16A Pressure Sensor

The silicon capacitive pressure sensor PMT16A has excellent accuracy, repeatability and long-term stability over a wide range of operating temperatures. Therefore, it maintains its accuracy and calibration for long periods of time, thus reducing the need for field calibrations.

The fine adjustment and calibration of the sensor at the factory are handled according to the electronic working standards, which are based on international standards.

Precipitation Sensors

QMR101

0201-009

Figure 14 QMR101 Rain Gauge

The QMR101 Precipitation Sensor is economical and accurate rain gauge of plastic material which is highly resistant to UV-radiation and

even frostproof. QMR101 has a self-emptying tipping spoon of 0.2 millimeters capacity. Due its small size, lightweight and rugged design, it is especially suitable for portable applications and temporary installations. QMR101 is installed on the sensor cross arm, and has ready-made cable with the connector.

QMR102

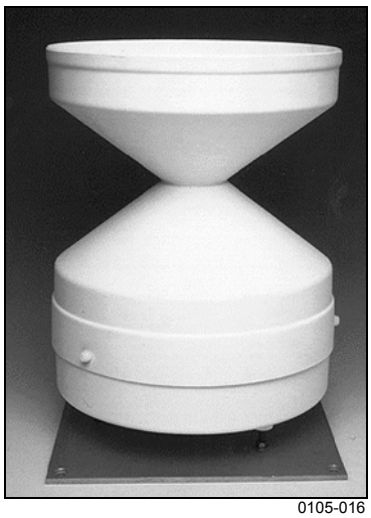

Figure 15 QMR102 Rain Gauge

An aerodynamically shaped rain gauge, Precipitation Sensor QMR102 is designed to minimize the wind-originated airflow reducing the catch. Manufactured from UV radiation resistant plastic, that makes it a very rugged instrument.

The collected rain is measured in a well-proven tipping bucket mechanism of 0.2 millimeters. QMR102 is installed on a stand or on a pedestal and it comes with a 6-meter cable and a connector.

Solar Radiation Sensors

QMS101

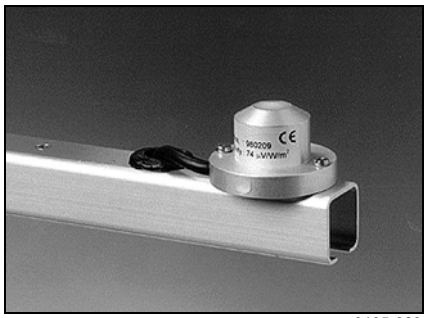

Figure 16 QMS101 Pyranometer

The QMS101 pyranometer is used for measuring global solar radiation. QMS101 uses a photodiode detector for creating a voltage output proportional to the incoming radiation. Due to the unique design of the diffuser, its sensitivity is proportional to the cosine of the angle of incidence of the radiation, thus allowing accurate and consistent measurements. QMS101 has a ready-made cable with a connector, and it is easily installed on the sensor support arm.

QMS102

Figure 17 QMS102 Pyranometer

QMS102 Pyranometer is an ISO/WMO-classified second class pyranometer. The precision optical glass dome acts as a filter, with a spectral band-pass that permits the full solar spectrum to pass through

to the sensor. The sensor is a high-quality blackened thermopile with a flat spectral response. Heating of the sensor by incoming solar radiation produces a signal in the microvolt range.

QMN101

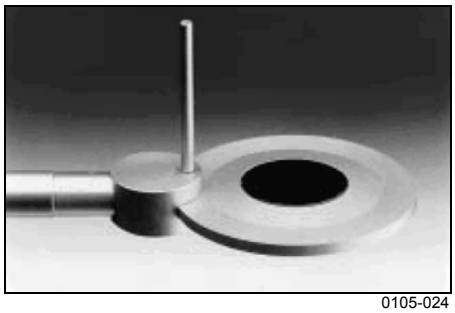

Figure 18 QMN101 Net Radiation Sensor

QMN101 Net Radiation Sensor is designed for routine measurements of net radiation. Net radiation is the balance between incoming and outgoing radiation in outdoor conditions. The sensor measures solar and far infra-red radiation balance.

The sensor is based on a thermopile and it consists of two Teflon-coated, weather-resistant black conical absorbers. The voltage output is proportional to the net radiation. Contrary to common instruments, QMN101 is virtually maintenance-free as it does not require fragile plastic domes.

Soil Temperature Sensors

QMT103

Figure 19 QMT103 Soil/Water Temperature Sensor

QMT103 Temperature Probe is particularly intended for precision measurement of ground and soil temperatures. All the materials have been carefully selected to withstand various environmental stress and wide temperature range. The measurement accuracy and stability of the temperature probe are based on a Pt-100 type sensor element specified to 1/4 DIN 43760B preciseness level. The probe includes a 5-meter cable with a black, weather-resistant polyurethane (PUR) sheath, which can tolerate both abrasive wear and extreme temperatures. Molded to the other end of the cable there is a 5-pin watertight connector, providing for instant assembly and replacement.

QMT107

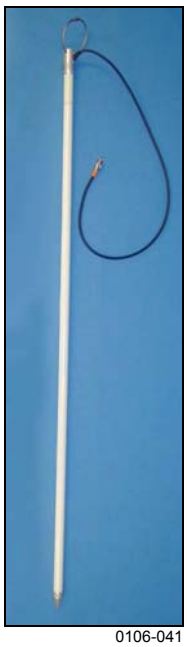

Figure 20 QMT107 Soil Temperature Sensor

The QMT107 probe is designed for the measurement of soil temperature and temperature profiles as a function of depth. Temperature measurement is based on resistive platinum sensors (Pt-100). There are seven temperature sensors located inside the probe. The sensors are positioned to +5 cm, ±0 cm, -5 cm, -10 cm, -20 cm, -50 cm, and -100 cm levels, where ±0 cm corresponds to the ground level mark of the probe.

The probe is constructed of glass fiber tube filled with epoxy, which makes the design watertight and provides low thermal conductivity. This ensures maximum accuracy as the sensor itself consumes very little power, thus causing almost no self-heating.

Soil Moisture Sensor

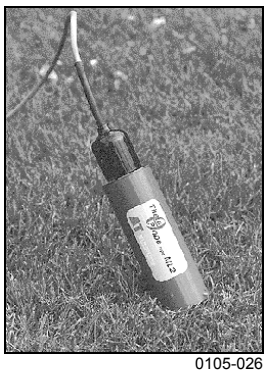
0105-026

Figure 21 ML2x Soil Moisture Sensor

ML2x Soil Moisture Sensor features a new technique with the accuracy of ± 2 % soil moisture.

Traditional low cost sensors made of gypsum block dissolve even in a short period of time when exposed to high moisture. The ML2x sensors are very durable. The rods are 60 mm long, made of resilient, solid stainless steel, and can be unscrewed and replaced if necessary. All exposed materials are either stainless steel or durable plastic, and the probes are fully sealed. This way they can also safely be buried into the ground.

The ML2x probes offer high accuracy and extended lifetime in permanent or temporary measurements of soil moisture.

Water Level Sensors

QMV101

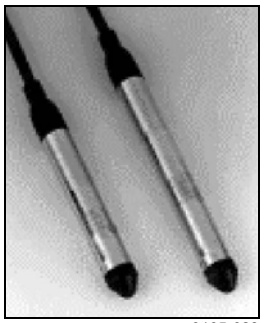
0105-028

Figure 22 QMV101 Water Level Sensor

QMV101 Water Level Sensor determines water level by measuring the water pressure above the submerged sensor in reservoirs, lakes, and rivers. The pressure measurement is based on high performance micro-machined silicon technology, packaged in a fully welded 316 stainless steel assembly.

The specific features include a Kevlar strain relieved vented cable, internal condensation protection and an IP68 injection molded cable assembly, which guarantees sensor operation over an extended period of time.

QMV102

0105-029

Figure 23 QMV102 Water Level Sensor

QMV102 Water Level Sensor determines water level by measuring the water pressure above the submerged sensor in reservoirs, lakes, rivers, and offshore. This transducer incorporates the latest advances in depth and level measurements. The highly stable pressure measurement is based on silicon measurement element fully isolated from the media by a titanium isolation diagram. The use of titanium enables the sensors to be used in the most hostile of fluids where materials such as stainless steel cannot be considered.

Leaf Wetness Sensor

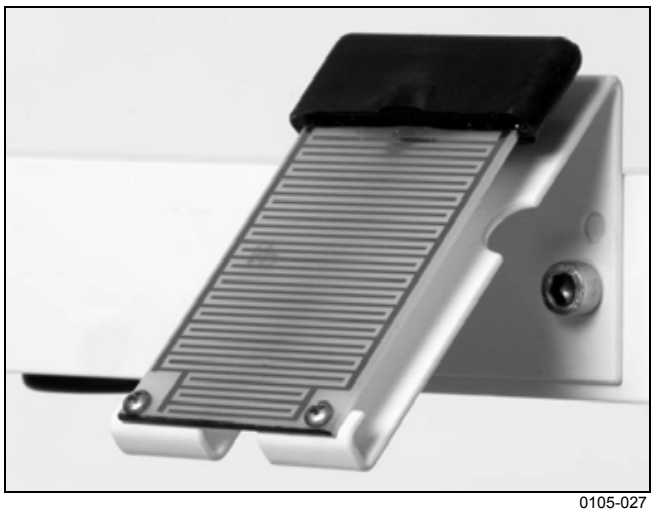

Figure 24 QLW101 Leaf Wetness Sensor

QLW101 Leaf Wetness Sensor enables MAWS to detect the presence of surface moisture on foliage and calculate the duration of wetness. When moisture is present, the sensor detects an electrical resistance change between the gold-plated elements of the grid.

Fuel Moisture Sensor

QFM101 Fuel Moisture Sensor measures the moisture content of the material on the forest floor or other natural area to help forest managers assess the fire danger. It uses a carefully selected and prepared pine dowel to exchange moisture with the environment. The sensor measures the moisture content of the dowel by its electrical capacitance.

A thermistor, located in the dowel where it fastens to the base, measures the temperature of the dowel giving the estimated temperature on the forest floor. This measurement is available as a second input to the controlling data acquisition system.

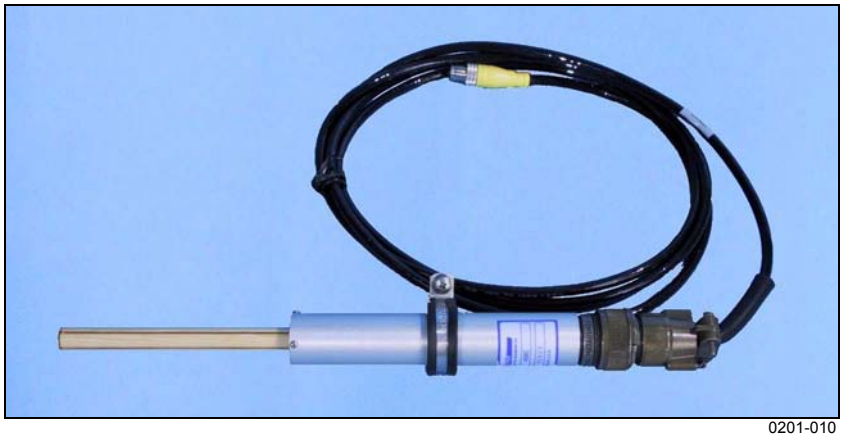

Figure 25 QFM101 Fuel Moisture Sensor

Communication Devices

Optionally, MAWS can be equipped with different types of communication equipment.

Communication Modules

MAWS has one RS-232 port as standard. Two optional plug-in modules can be used for enhancing the number of the serial I/O channels up to five.

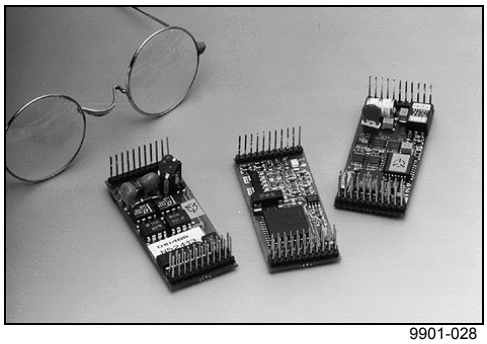

Figure 26 Communication Modules

DSU232

The DSU232 is an unisolated RS-232 module that will provide either a double serial channel without handshaking or a single RS-232 with handshaking. It has an ability to feed 12 V (45 mA) for serial sensors.

The power consumption is less than 10 mA when communicating, less than 1 mA at standby.

DSI485A

DSI485A is an isolated communication module for providing the 2- or 4-wired RS-485-communication link between MAWS and another piece of equipment with a similar interface. The DSI485A module is used e.g. for connecting displays and terminals to MAWS when the distance is longer than 15 meters. The maximum distance for DSI485A is approx. 1500 meters at full speed. The power consumption is from 10 to 25 mA when communicating, 1 mA at standby.

The DSI485A module must be configured before using it so that it works as desired. The Lizard Setup Software is used for this purpose.

DSI486

DSI486 is a dual-isolated communication module, which can be used in RS-232, RS-485, or SDI-12 mode. The communication mode is selected by the correct wiring of the I/O pins and with the correct jumper settings on the board. The DSI486 module is used, for example, for connecting displays and terminals to MAWS when the distance is longer than 15 meters. The maximum distance for DSI486 is approximately 1500 meters at full speed.

The RS-485/422 channels A and B are galvanically isolated from the host board's electronics. The +5 VDC power supplies of channels A and B are also isolated from each other with capacitors. Thus, it is possible to wire these two channels to separate locations.

The RS-232 mode utilizes channel B. When channel B is used in the RS-232 mode, it is possible to use channel A as a galvanically isolated two-wire RS-485 channel. The RS-232 channel is galvanically connected to the host board's GND potential.

The SDI-12 channel has its own connecting point on the board. It does not use channel A or B for the communication. SDI-12 is galvanically connected to the host board's GND potential.

The DSI486 module must be configured before using it so that it works as desired. The Lizard Setup Software is used for this purpose.

Modem DMX501

The DMX501 communication module is used for providing long distance fixed line connection between MAWS and another Vaisala equipment with a similar interface, max. distance up to 10 km.. Through this I/O port, MAWS can send reports and data or the host can poll them.

The DMX501 modem module supports the following communication standards:

- V.21, 300 bps FSK
- V.23, 1200 / 75 bps FSK
- V.22, 1200 bps DPSK

The DMX501 modem module must be configured before using it so that it works as desired. The Lizard Setup Software is used for this purpose.

SATELLINE 3AS Radio Modem

0201-011

Figure 27 SATELLINE 3AS Radio Modem

The SATELLINE 3AS radio modem is a half-duplex radio modem suitable for high-speed data applications. As an UHF radio modem, it provides the data speeds 19200 bps at 25 kHz and 9600 bps at 12.5 kHz in the air. RS interface data speed is user selectable from 300 to 38400 bps. The connection between MAWS and the radio modem is established by using RS-232. The radio modem comes with a ready-made cable (approx. 0.5 m) and a special weatherproof enclosure.

SATELLINE 3AS radio requires 12 VDC voltage for powering, therefore a mains power supply or QMP201C must be used with the radio modem. In addition, a wiring change must be made in the logger. For details, see the installation instructions. The SATELLINE 3AS radio modem must be configured before using it so that it works as desired. The provided setup software is used for this purpose.

Accessories

Masts for MAWS101

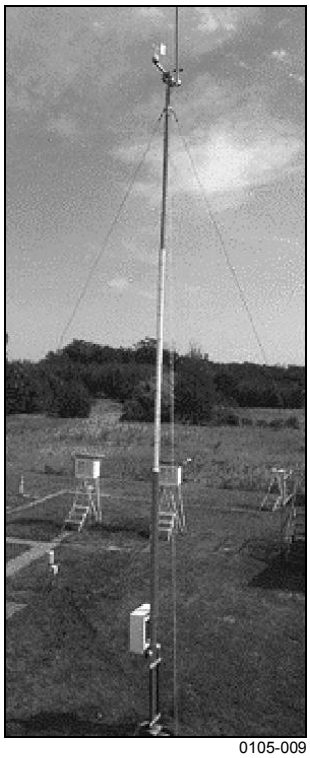

Figure 28 Installation Mast with Accessories

DKP102

DKP102 is a 2-m high pole mast designed for MAWS101 system. When using DKP102 mast, the wind sensor must be QMW101. Together with wind sensor installation pole, the total height of the wind sensor will be approximately 3 meters.

DKP12

DKP12 is a 10-meter pole mast used for equipment installation. The mast is made of anodized aluminum resisting well even the most harsh weather condition. The mast is equipped with a lightning rod and a set of guy wires. The mast base and the guy wires require a solid concrete base. The recommended grounding resistance is less than 10 ohms.

Sensor Arm

0201-012

Figure 29 QMA101 Sensor Arm

Sensors are installed on the QMA101 sensor arm. The arm includes factory made drillings for every sensor model to be installed. In MAWS201 totally three sensor arms can be installed to the tube. In MAWS101 totally five sensor arms can be installed.

Carry Case Sets

The carry cases for the Vaisala MAWS201 are made of cellular polypropylene (EPP). This lightweight but very rugged material provides excellent cushioning during transport. The cases are equipped with handles, hinges and latches for which padlocks can be used. The larger case for the tripod is also equipped with a pair of wheels. There are two sets of carry cases to choose from.

QMM110

The QMM110 Basic Set consists of one hard case for the sensors and accessories, and one soft canvas case for the tripod, solar panel, wind mast, as well as hammer and ground pegs.

0201-013

Figure 30 QMM110 Carry Case Set

QMM120

The QMM120 Extended Set consists of two hard cases, one for the sensors and accessories, and another one for the tripod, solar panel, wind mast, as well as hammer and ground pegs. The smaller case weighs only 3.6 kg and the larger 9.2 kg.

0201-014

Figure 31 QMM120 Carry Case Set

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CHAPTER 3

INSTALLATION

This chapter describes how to mechanically put together a MAWS weather station that is mounted to a portable mast or to a pole mast. For the installation instructions of the MAWS Terminal software and the setup software MAWS Lizard, see the User's Guides listed in Table 2 on page 15.

Table 8 Overview of Installation

Section	Questions answered
Introduction to MAWS, on page 17	What is a MAWS station made of? How are the parts called in this manual?
Preparing Installation, below	What tools are needed, how to unpack the delivery?
Siting the Station, on page 48	Where to install the station and the sensors?
Installing MAWS Basic Components, on page 53	How to assemble basic components?
Installing MAWS101 to a Mast, on page 57	How to install MAWS101 to a pole mast?
Installing MAWS201 to the Tripod, on page 62	How to install MAWS201 to the tripod? How to set up a mobile station after transportation?
Disassembly of MAWS201 for Transportation, on page 97	How to pack MAWS for transportation?

Preparing Installation

Make sure you have all the necessary tools at hand. The Tools Bag supplied with the tripod mast includes a set of tools that will be needed during installation.

Tools needed:

- Compass (not supplied), or other methods to establish the right orientation of the station
- Screwdrivers: 3 mm (in the Tools Bag)
- Hex wrenches: 4 mm (in the Tools Bag)
- Hammer for hitting the ground pegs into ground (in the Tools Bag of the MAWS201 delivery)
- Pegs for securing the tripod (in the Tools Bag of the MAWS201 delivery).

Additional special tools for the different sensors are provided in their packages.

One person can complete the whole installation. Depending on the set of sensors, the installation should not take more than half an hour.

Unpacking Instructions

When you have received the delivery, first see that you have all the ordered components. Secondly, check the sensors. Make sure are that they have not been damaged during transportation.

User manuals and special tools included in the packages should be stored in a safe place for later use.

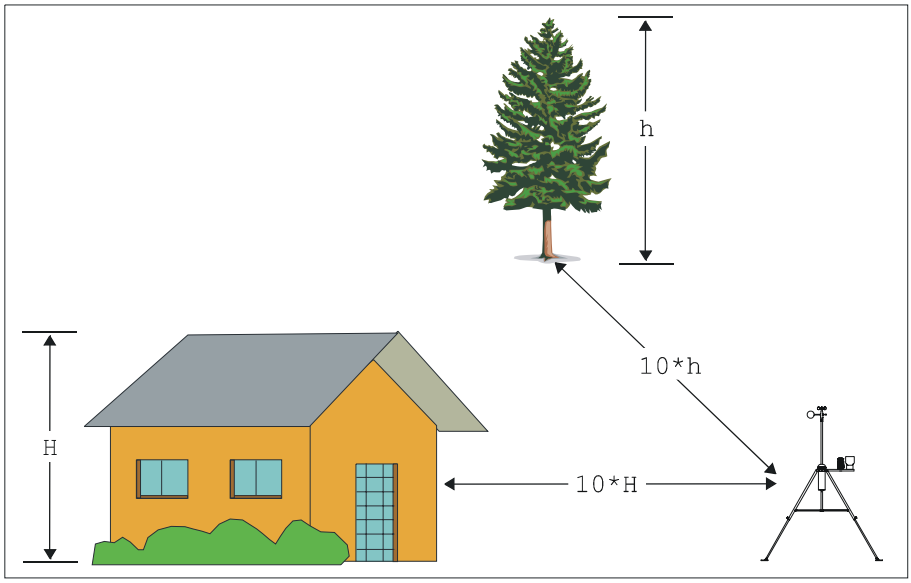
The logger electronics are attached to the railing inside the tube. Also the tripod is already assembled, but needs to be attached to the tube structure (see Assembling the Tripod on page 63).

Siting the Station

Finding a suitable site for the weather station is important for getting representative ambient measurements. Normally, the suitable site should represent the general area of interest. When locating the weather station, consider the items presented in the following sections. The descriptions are not exhaustive, for further information refer to local and WMO recommendations.

Wind

Allow sufficient clearance for the wind sensors, that is, the station should not be located next to a building or any other object that might affect the airflow.



0201-015

Figure 32 Siting the Station

In general, any object of height h will not remarkably disturb the wind measurement at a minimum distance of 10×h. For example, locate the weather station at least 30 meters away from a 3-meter high tree. See Figure 32 above.

Air Temperature and Relative Humidity

NOTE	The radiation shield is important in protecting the sensor from direct sunlight and must always be used.

For MAWS201, a suitable height for the sensor is already determined by the tripod. For MAWS101 in mast installations, the height should be set to 1.5 to 2 meters. In the northern hemisphere, the sensor should usually be on the northern side of the mast. Avoid the following installation sites to ensure correct measurements: shaded areas,

rooftops, steep slopes, heat sources, swamps, high vegetation and places that might hold water after rains.

Precipitation

Rain gauge QMR101 is installed on the same sensor arm with the temperature and humidity probe. Rain gauge QMR102 is installed on the ground, on a base plate, or on a separate stand near the logger.

The orifice of the gauge must be in a horizontal plane, open to the sky, and above the level of in-splashing and snow accumulation. In general, objects should not be closer to the gauge than a distance twice their height above the gauge orifice.

In areas of homogeneous dense vegetation, the height of the vegetation should be kept below the gauge orifice level by regular clipping. Sites on a slope or on the roof of a building should be avoided. Also hard flat surfaces such as concrete should be avoided to prevent excessive in splashing.

Solar Radiation

Make sure that no building or object will shadow the station, especially the solar panel and solar radiation sensors, during the day.

On the Northern Hemisphere, the solar radiation sensors should be installed on the southern side of the MAWS (on the Southern Hemisphere, vice versa) to avoid other weather station structures shading the sensor. To facilitate leveling/cleaning, installing at a height of 3 m or less is recommended.

The solar panel should face south (true south, not magnetic) on the Northern Hemisphere and north on the Southern Hemisphere.

See also Figure 97 on page 102.

Soil Temperature

Finding a suitable site for QMT103 or QMT107 Soil Temperature Probe is important for getting representative soil temperature measurements. Measurement site should be 1 m² and typical of the surface of interest. The ground surface should be level with respect to the immediate (10 m radius) area.

The QMT107 probes are pressed into pre-formed holes, but they can also be placed into excavated holes that are then filled. On hard or rocky ground, a pilot hole is pre-formed with an auger rod.

Soil Moisture

The soil water content measured by the ML2x sensor within one small locality can be affected by:

- Variations in soil density and composition
- Stones close to the rods
- Roots (either nearby or pierced by the rods)
- Earth worm holes or mole holes
- Subsoil drainage
- Small scale variability in transpiration and evaporation losses.

It is important to take the degree of variability of these parameters into account when deciding on the number of probes to be used at any particular location. If the soil is known to be very heterogeneous, it will be necessary to take measurements from at least three closely-spaced locations.

Water Level

Place the QMV101 and QMV102 sensors according to the following examples. Refer to Figure 33 on page 52.

Example 1: Average water level is 25 meters and maximum annual change is 50 cm. Suitable sensor is with range of 75 cm and installation place is 24,6 meter from ground level.

Example 2: In dry season the riverbed is dry and in rain season the ultimate water level is 7 meters. Suitable sensor would be with 10-meter range. If interested values start after water level is greater than 3 meters, it is possible to use 5-meter version and install it to 3 meters from ground.

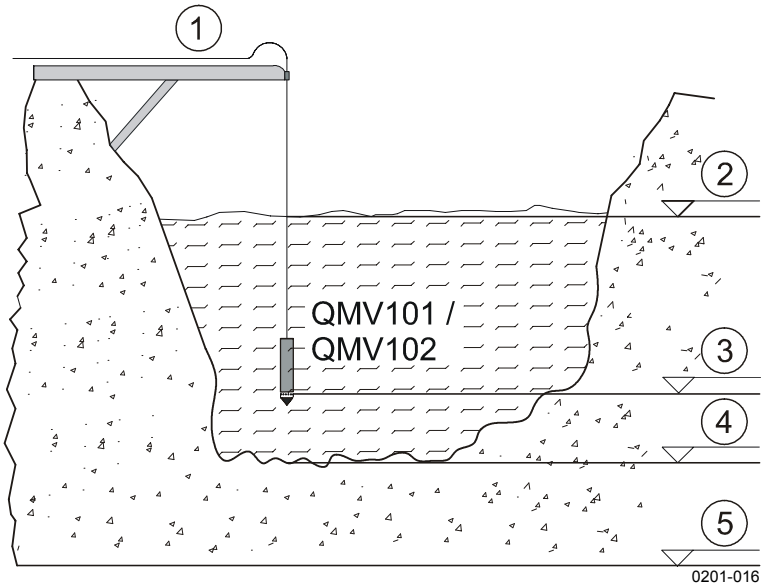


Figure 33 QMV101/QMV102 Sensor in Water

The following numbers refer to Figure 33 above:

1 = Cable to MAWS
2 = Water level
3 = Sensor level
4 = Local reference
5 = Common level

The sensor should always be protected against the flow and impurities in the river using, for example, the stilling well or protective plastic piping.

Fuel Moisture

QFM101 Fuel Moisture Sensor can monitor the moisture conditions on the forest floor only if it can absorb and give up moisture near a fair sample of the material that is naturally present. It must exchange moisture with the air in essentially the same way that the forest floor materials do.

Mount the sensor on the south side of the tower (or the north side in the southern hemisphere) so that it is not shadowed by the tower. If possible, arrange that the sensor is exposed to sunlight for at least six hours in the middle of the day. Make sure that no grass or other vegetation touches the sensor; these can transfer moisture directly. The sensor must be installed approximately one week before it can give an accurate reading of the fuel moisture on the forest floor.

Installing MAWS Basic Components

The installation of the basic components is done only when taking the MAWS weather station in use for the first time. Some of the steps are applicable also in the normal use of the portable MAWS201 station.

NOTE	The figures in the procedure are taken from installing the MAWS201. In case you are installing MAWS101, you do not have any of the tripod's parts attached as shown in some of the figures.

1. Loosen and remove two hand screws (1) beneath the tube. Slide the tube (2) down to expose the logger.

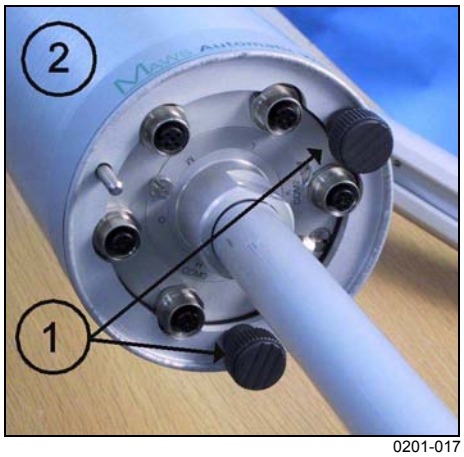


Figure 34 Tube Securing Hand Screws

2. Remove the logger cover screw (1) to open the logger housing.

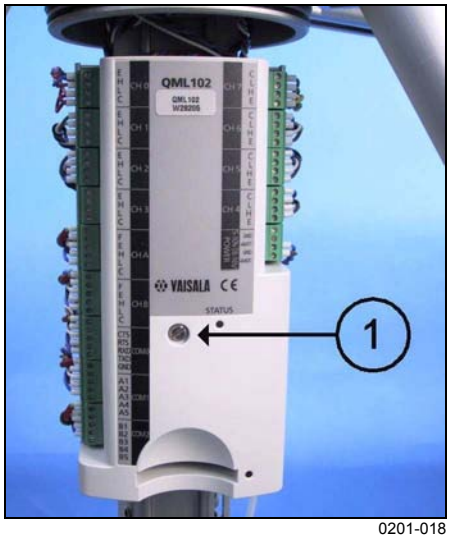


Figure 35 Logger Cover Screw

3. When you have the PMT16A pressure sensor (1) installed on the logger, attach the tube that comes from the blue inlet (3) into the outlet (2) of the logger housing. The tube should cover at least 5 mm of the outlet. Make sure that the tube is not blocked or bent during the transportation.

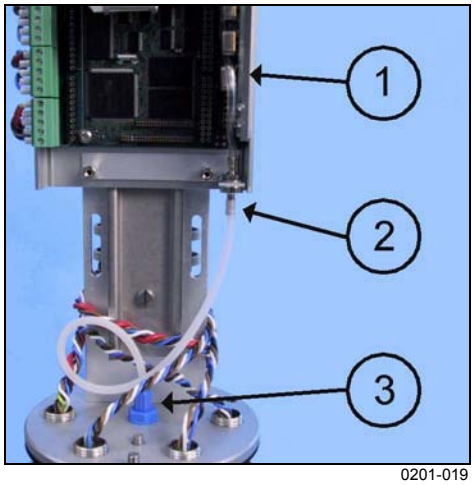


Figure 36 Pressure Sensor Tube Connection

4. The internal battery should always be installed when the weather station is in operation. The battery supplies backup power to the station and is needed for keeping the time and date information. To insert the internal battery, you may have to bend battery terminals. Connect the flat connectors to battery terminals (1 & 2). Connect the red wire to the positive pole (+), and the black wire to the negative pole (-). The battery lead(s) is disconnected during shipping. It is recommended to disconnect the lead also if the station is not used for several weeks (no charging). When storing the station for a few days, use **SLEEP** command to reduce the power consumption and discharging the battery.

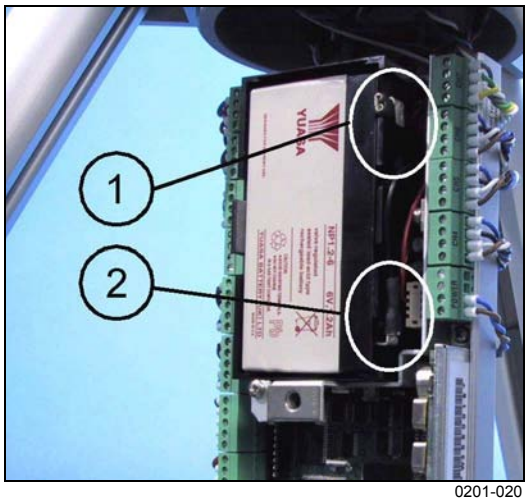


Figure 37 Battery Connectors

5. Rotate the tube to find the correct aligning pin (1) position. Slide the tube up. Tighten it with two hand screws (2). To keep the tube watertight, the tube should cover the two O-rings (1 & 2) on the bottom of the upper base.

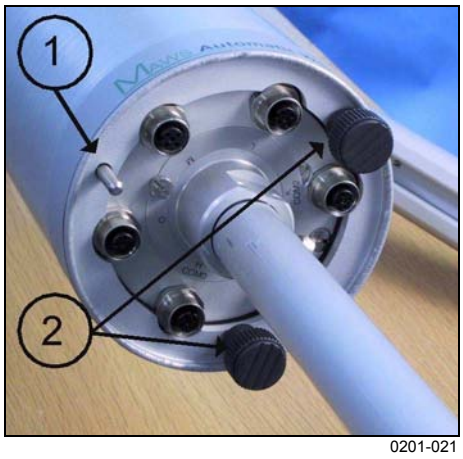


Figure 38 Aligning Pin and Hand Screws

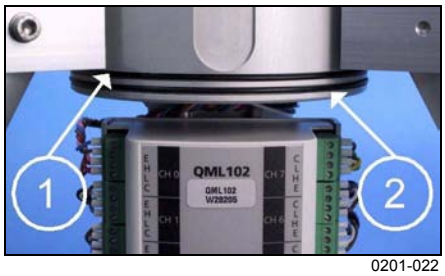


Figure 39 O-rings for Sealing the Tube

6. Attach the wind sensor adapter to the top of the upper tube. Tighten with the small hex screw (1). For vane alignment instructions, see section Aligning Wind Vane on page 73. Guide the wind sensor cable through the upper tube and connect it to the sensor. Affix the sensor into its place by tightening the plastic collar (2).

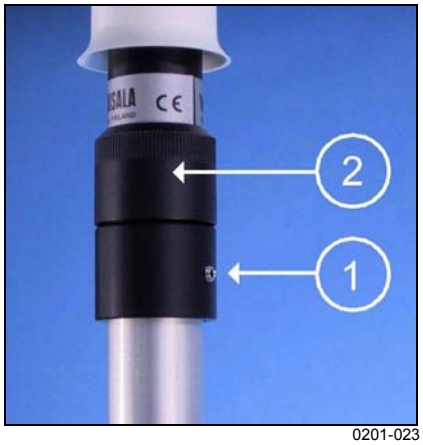


Figure 40 Wind Sensor Attachment

7. Attach the upper tube to the base. Guide the tube into its place with the notch (1) facing the screw (2). Press the tube all the way down and tighten the hex screw (2). Take the wind sensor cable out through the opening (3).

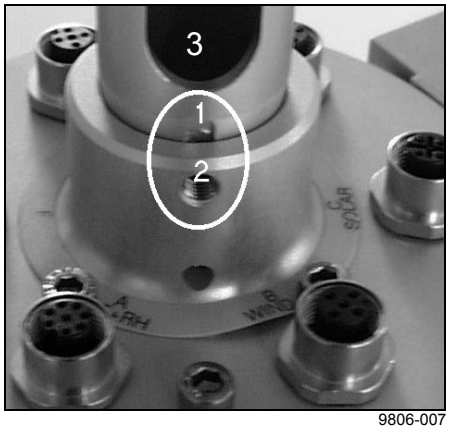


Figure 41 Upper Tube Attachment

8. Attach the sensor arm supports (2) to the upper base. Tighten the screw properly with an Allen key (1).

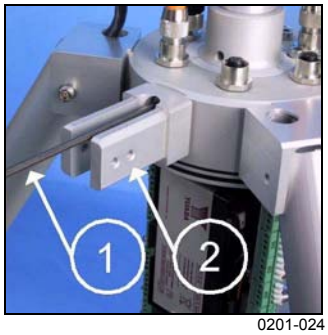


Figure 42 Sensor Arm Support Attachment

9. Attach the sensor arm(s). Fit the cables into the opening (1) before tightening the attachment screws (2 & 3). For installing the sensors, see section Installing Sensors on page 71.

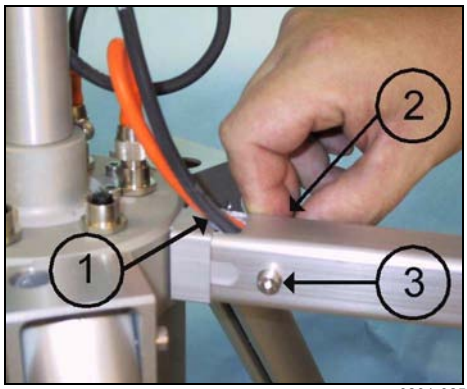


Figure 43 Sensor Arm Assembly

Installing MAWS101 to a Mast

MAWS101 can be installed in several ways:

- Using the 2 meter high mast DKP102.
- Using the 10 meter high mast DKP12.
- Using any wooden pole or wall.

On DKP102

The stud bolts and anchors for installing the mast are delivered with the mast. Typically, the mast is installed on an existing concrete foundation (with a minimum size of 500 × 500 × 300 (mm)) or on a rocky bed. Drill holes into the foundation as described in Figure 44 on page 58. After that, fasten the stud bolts to the anchors by hand.

Protect the tops of the bolts with two nuts tightened together. Place the combinations into the holes, anchors down, and hammer them down. Tighten the bolts a few times to ensure that the anchors attach to the walls of the holes. Fix the pedestals with the washers and nuts.

Alternatively, the stud bolts can be encased in concrete. In this case, the bolts should be kept safely at the correct position during pouring the concrete in. You should also protect the stud bolts from the concrete during casting to avoid problems in installing the pedestals.

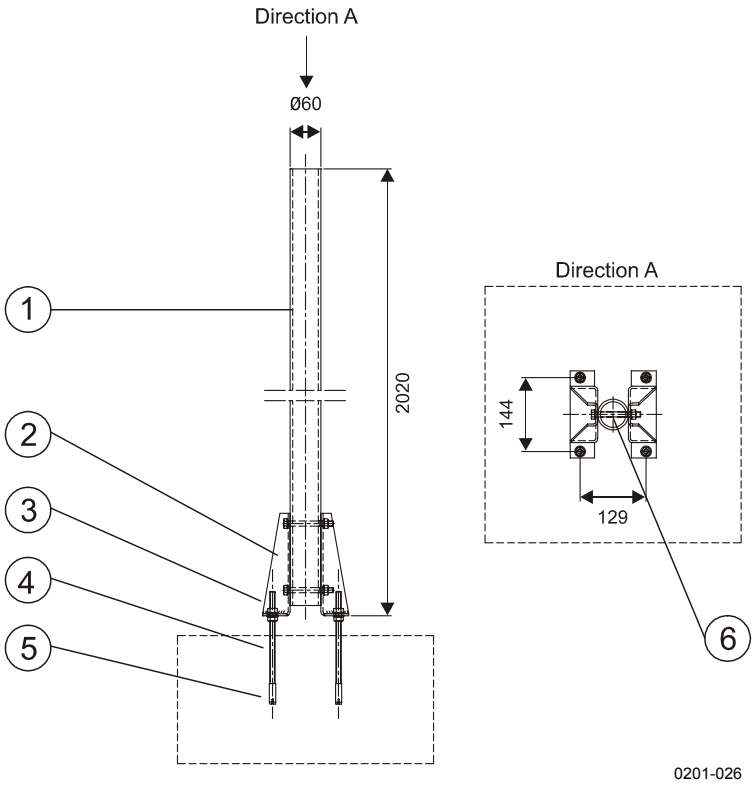


Figure 44 DKP12 Attachment to a Foundation

The following numbers refer to Figure 44 above.

1 = Mast
2 = Pedestals 2 pcs
3 = Nuts M10 DIN934 8 pcs
Washers A10.5 DIN125 8 pcs
4 = Stud bolts M10x200 4 pcs
5 = Anchor M10 L=40 4 pcs
6 = Bolts M10x90 DIN933 2 pcs
Washers A10.5 DIN125 4 pcs
Nuts M10 DIN934 2 pcs

The MAWS101 delivery includes an installation arm and four clamps for fixing the arm to a pole mast. There are two sets of clamps included: one for 60 mm diameter pole and one for 100 mm diameter pole. The smaller clamps are intended for use with the 2-meter high DKP102 mast. Use the QMW101 wind sensor with the DKP102 mast.

9906-025

Figure 45 Maws101 Fixed to the Pole with Clamps

On DKP12

Another option is to use the 10-meter high DKP12 mast. Install the arm to the DKP12 mast with the large clamps. Use the wind sensor QMW110 because it includes a 10 meter cable. Fix the upper tube with the wind sensor to the top part of the mast with the smaller clamps (see Figure 46 on page 60).

Figure 46 Wind Sensor QMW110 with DKP12 Mast

The 10-m cable is used for connecting the wind sensor to the connector "Wind" on the upper base of the MAWS. A protective cover screw, included in the shipment, holds the protective cover in place above the upper base (see Figure 47 below).

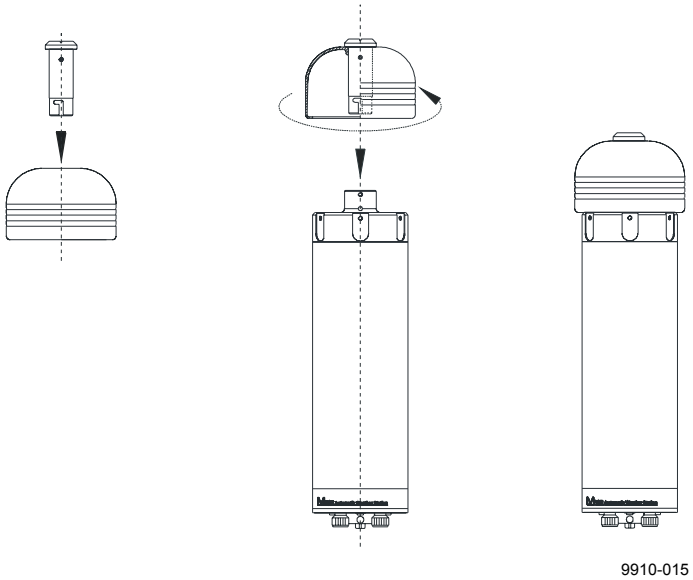


Figure 47 Installing the Protective cover Screw

On Any Wooden Pole or Wall

The installation arm includes two holes for fixing the arm to any wooden pole or wall. For details, see Figure 48 below and Figure 49 below.

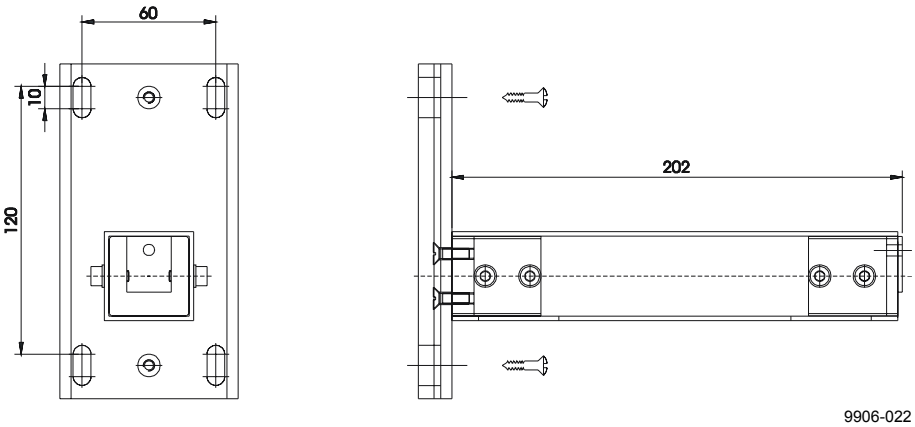


Figure 48 Installation Arm

Figure 49 MAWS101 Fixed to a Wooden Pole with Screws

Installing MAWS201 to the Tripod

MAWS201 always has a tripod for supporting the logger tube. One or more sensor arms are connected to the tube. The legs of the tripod are adjustable. The pegs should be used to prevent the collapse of the station. For the wind sensor installation there is a separate tube attached to the upper base of the logger tube. The schematic structure of the installed MAWS201 is presented in Figure 50 below.

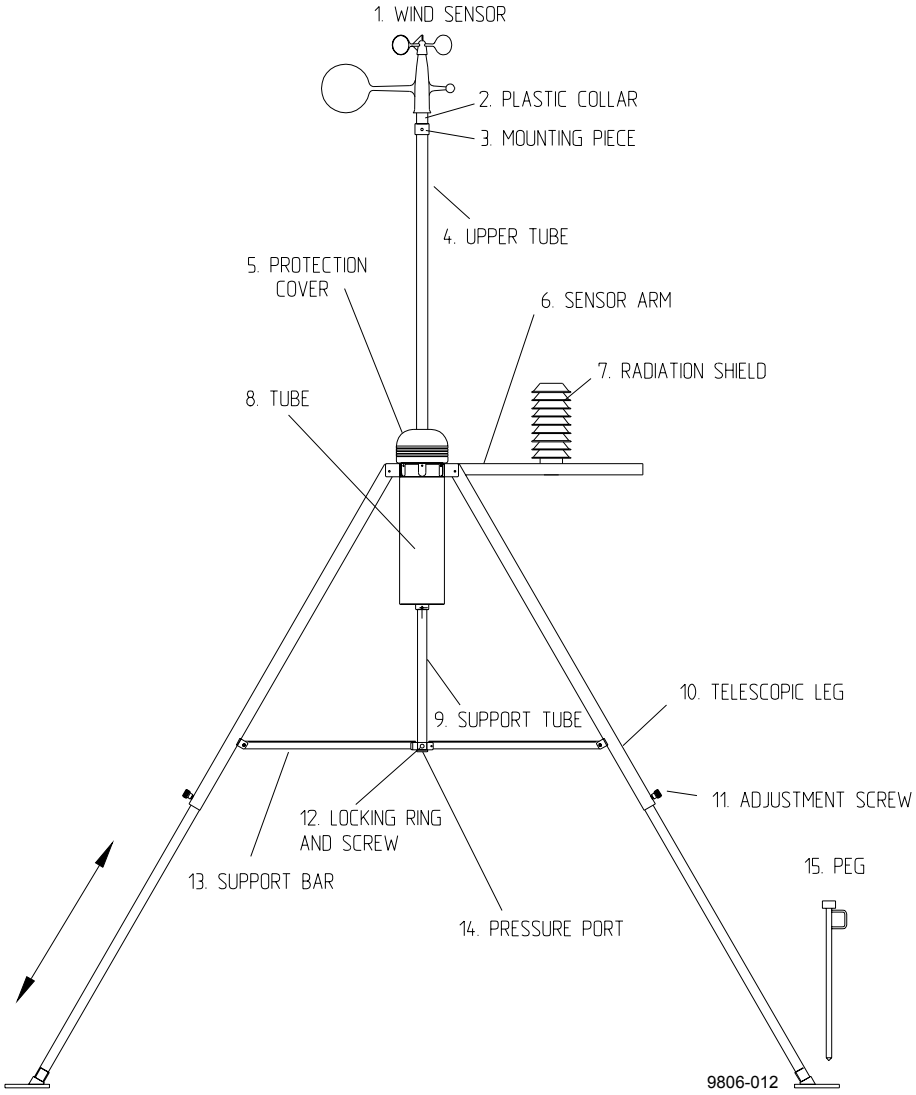


Figure 50 Mechanical Structure of MAWS201

Assembling the Tripod

Normally the tripod is installed at the factory, and you can begin erecting the station as instructed in the step 2 below.

1. Attach the leg fasteners (1) to the upper base. Lock the leg (2) to the leg fastener with a bolt (3).

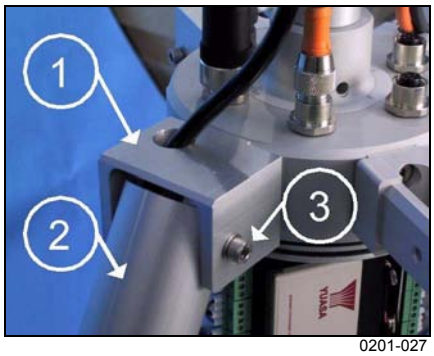


Figure 51 Tripod's Leg Attachment

2. Place the tripod in an upright position. Loosen the locking ring, spread the legs and lock by tightening the screw. The support bars should be horizontal. See Figure 50 on page 62 for component names.
3. Adjust the height of the legs. Loosen the hand screws (1) at the lower end of the legs, extend or shorten as required and lock by tightening the screws. Hammer the peg through the hole (2) to the ground to secure the leg. If the ground is too hard for the pegs, fill the tool bag with sand and/or stones. Attach the bag to the support bar with the straps.

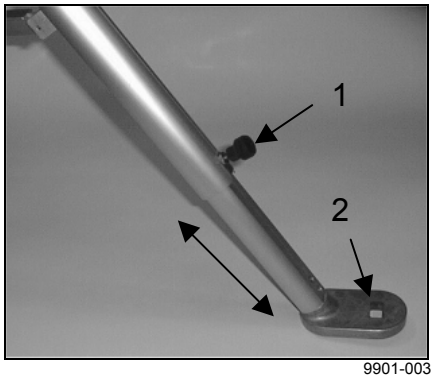


Figure 52 Tripod's Leg Adjustment and Peg Hole

Installing Power Supply

Installing Solar Panel

Usually the solar panel is installed at the factory, and you should only adjust the tilt angle and check that the connector is attached.

1. Locate the leg where the solar panel is to be installed. Note the alignment of sensor arms vs. solar panel. See Figure 97 on page 102. Open the bolt (3) of the leg fastener (1) to release the leg (2).

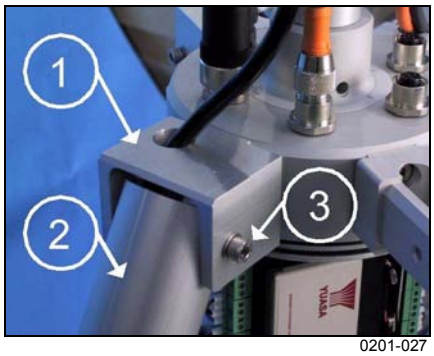


Figure 53 Tripod's Leg Attachment

2. Glide the solar panel fixture down the leg so that the fixing piece (1) inside the leg fit over the leg profile. When the fixture is at suitable height, tighten the screws (4). Place the panel on the fixture and tighten the screws (3 and 5). Fit the cable (2) inside the leg and guide it through the hole in the leg fastener (1 in Figure 53 above). Put the leg back into the leg fastener and tighten the bolt (3 in Figure 53 above).

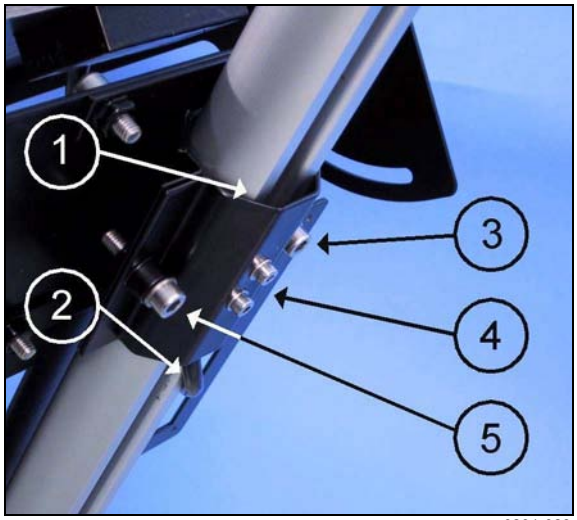


Figure 54 Solar Panel Fixture

3. To set the correct tilting angle, slightly loosen the fixing bolts (1) and the adjustment bolts (2). Tilt the panel to the suitable angle, see Table 9 on page 68. Finally, tighten the bolts. Note the cable (3) when adjusting the angle.

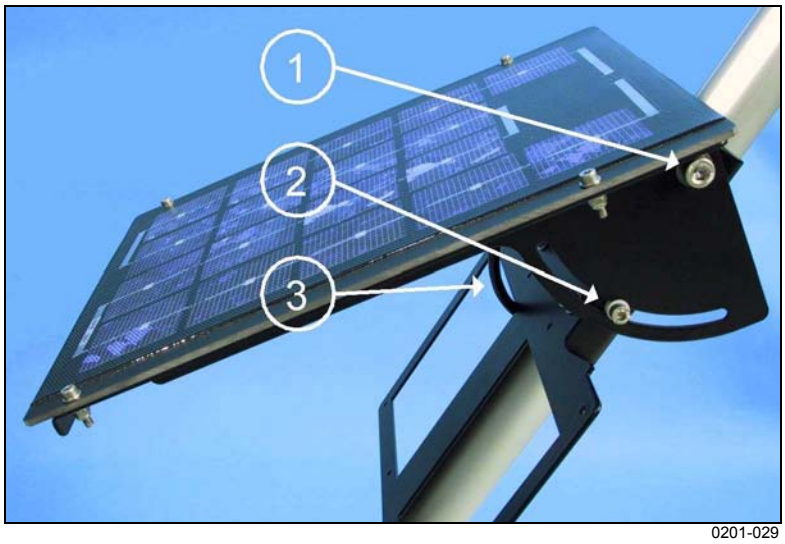


Figure 55 Solar Panel Angle Adjustment

4. Thread the cable through the connector parts in the indicated order 1-2-3-4. Parts for a metallic connector are shown in Figure 56 on page 66. Parts for a plastic connector are shown in Figure 57 on page 66.

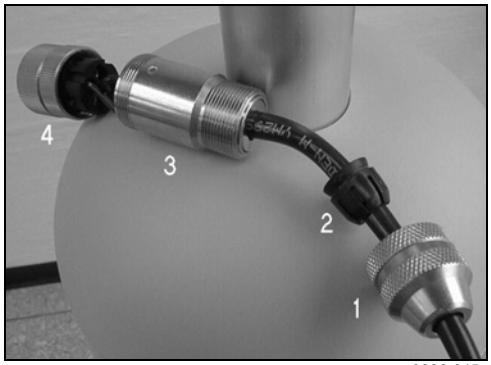


Figure 56 Metallic Connector for Solar Panel

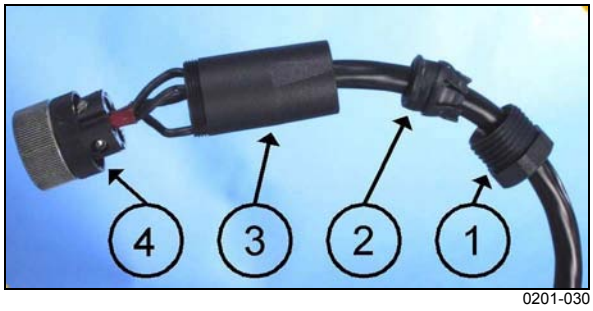


Figure 57 Plastic Connector for Solar Panel

5. Insert the wires numbered 1 and 2 into the terminal 1 and the wires numbered 3 and 4 into the terminal 3. Tighten the screws that hold the wires.

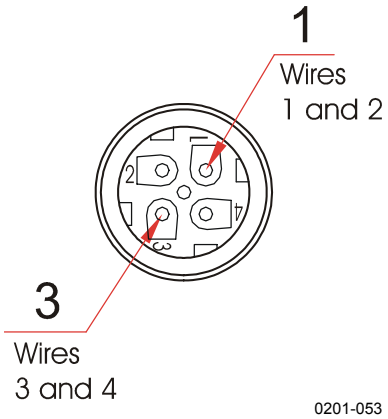


Figure 58 Wires' Connection to the Terminals

NOTE	In the following two figures only the metallic connector is presented, although the procedure is the same with the plastic connectors.

6. Tighten part 3 to connect it with part 4. Insert the sealing part (2) into part 1. Tighten part 1 to part 3.

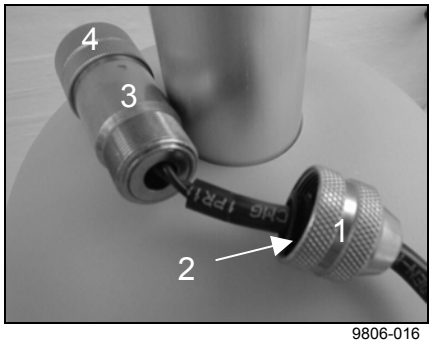


Figure 59 Solar Panel Connector Assembly

7. Attach the plug to the Solar connector (1) by tightening the lowest nut (2).

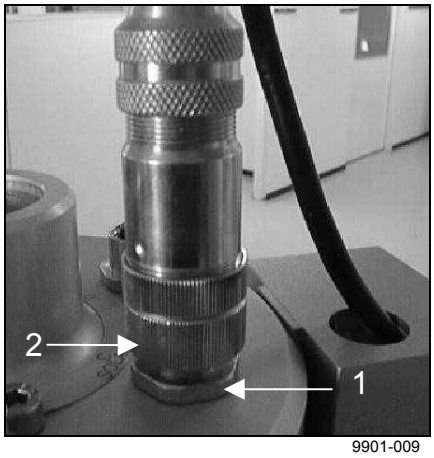


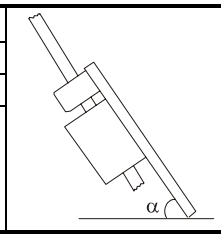
Figure 60 Connector Attached

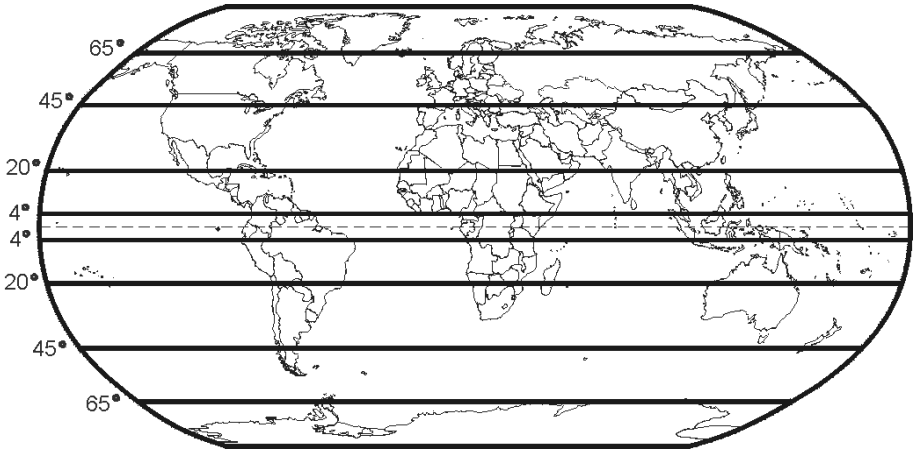
The panel should face south (true south, not magnetic) on the Northern Hemisphere and north on the Southern Hemisphere (see Figure 97 on page 102). The panel can be tilted towards the sun: the further you are from the equator the more vertical the panel.

To maximize the annual energy output, install the panel at an angle explained in Table 9 on page 68. At some installations, it may be effective to adjust the tilt seasonally. At most latitudes, performance can be improved during summer by using an angle smaller than the table's recommendation. Conversely, a larger angle can improve winter performance.

NOTE	The rays of the sun should be perpendicular to the panel, which means sunlight should hit the panel at a 90° angle.

Table 9 Recommended Tilt Angle for Solar Panel

Latitude of site	Tilt angle (α)	
0 ...10°	20°	
10 ... 50°	Add 10° to local latitude	
> 50°	60°	



0011-042

Figure 61 Map of Latitudes

WARNING Photovoltaic modules generate direct current (DC) when exposed to sunlight or other sources of light. Although single modules produce low voltage and current, shocks and burns can still result from contact with module output wiring. *PV modules do not have to be "connected" (i.e., powering a load) to generate electricity. Since modules produce electricity whenever light is preset, the module should be completely covered by an opaque cloth or other material before electrical connections to the modules or other system components are handled*

WARNING When working with modules, use properly insulated tools and wear rubber gloves.

CAUTION	Handle with care: impact on the front or rear surface can damage the module. Do not bend the module.

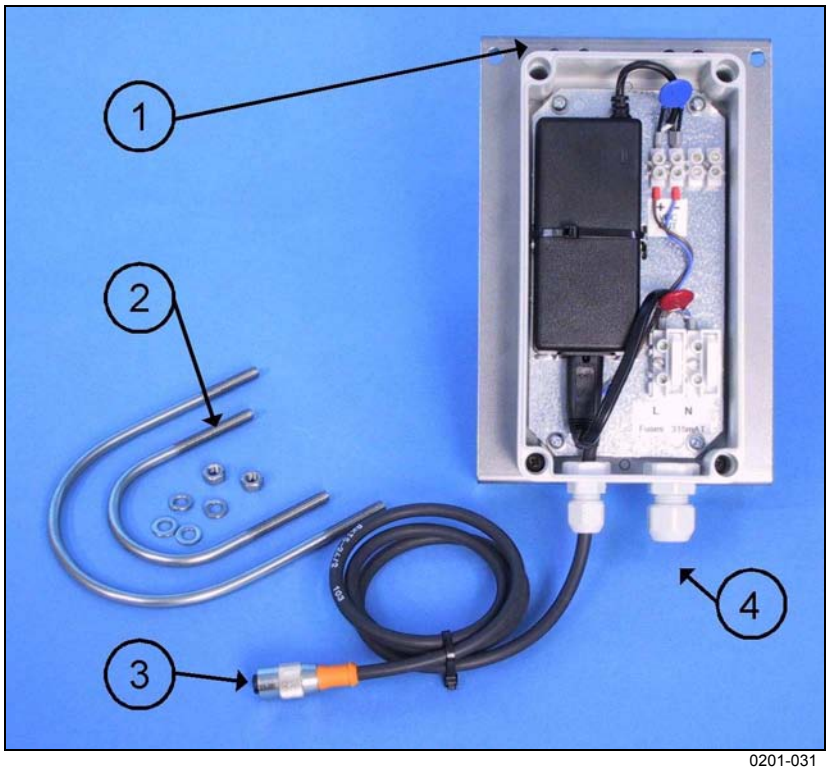
NOTE	Do not concentrate light on the module in an attempt to increase its power output.

Installing a QMP Power Supply

MAWS can be powered from a QMP power supply. For the alternatives, see section Power Supplies on page 25.

QMP213 Mains Power Supply

QMP213 Mains Power Supply is delivered with the U-bolts, washers, nuts, and the connector cable for MAWS. The unit is attached to the mast.



0201-031

Figure 62 QMP213 with Installation Accessories

To install the unit, follow the procedure below:

1. Attach the unit through the holes in the upper end (1) with the provided accessories (2) to the mast. The cable inlets should face down.
2. Lead the mains power cable through the opening (4) and connect the wires under the screws into locations marked with L and N. Tighten the inlet nut properly.
3. Connect the output power cable (3) to the power connector of MAWS, see section Connecting Cables on page 71.

QMP201C Solar/Mains Power Supply

QMP201C Solar/Mains Power Supply is delivered with a connector cable for MAWS. The unit is attached to the tripod's leg.

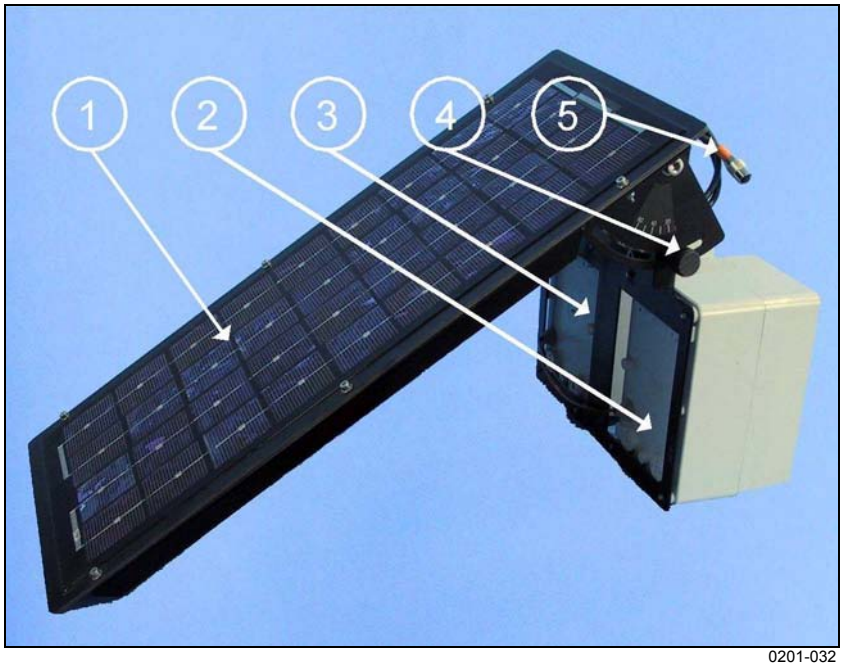


Figure 63 Parts of QMP201C

The following numbers refer to Figure 63 above.

1 = Solar Panel
2 = The box for the backup battery
3 = The box for the mains power supply and battery regulator
4 = The angle adjusting hand screw
5 = The connector cable

To install the unit, follow the procedure below:

1. See section Installing Solar Panel on page 64 for mechanical installation instructions.
2. Attach the cable (5 in Figure 63 on page 70) to the power connector of MAWS, see section Connecting Cables below.
3. Adjust the angle of the solar panel as described in section Installing Solar Panel on page 64.

Installing Sensors

The mechanical installation of the sensors is presented in the following sections.

Connecting Cables

After installing the sensors mechanically, follow the instructions in the steps below to connect the cables. Step 1 is for the lower base of the tube and step 2 is for the upper base of the tube.

NOTE	Be careful when connecting cables so that the connector pins will not bend.

1. Connect the sensor cables to the connectors on the lower base and tighten the screw nuts. For connector description, see Table 10 below.

Table 10 Default Lower Base Connectors

Connector	Sensor/Device
(H) COM0	Terminal
(I) COM1	Communications or sensors with RS-232 interface
(K) COM2	Communications or sensors with RS-232 interface
(L)	QMT103 or QMT107
(M)	Additional sensor
(O)	Additional sensor

2. Connect cables to the connectors on the upper base and tighten the screw nuts. For connector description, see Table 11 below.

Table 11 Default Upper Base Connectors

Connector	Sensor/Device
(A) T+RH	QMH101
(B) Wind	QMW101
(C) Solar	Power supply (solar panel or mains power)
(D)	QMR101 or QMR102
(E)	QMS101 or QMS102
(F)	QMN101

3. Finally, lower the protection cover on the upper base to shield the connectors.

Installing Pressure Sensor

The PMT16A Pressure Sensor is located on the CPU board of the logger, see Figure 64 on page 73. Normally, it is factory installed on the logger board. If necessary, it can be accessed by removing the cover of the logger. The sensor is connected directly into the connector on the board and is fixed on it by one screw.

CAUTION When handling the sensor, take care not to bent any components on the transducer board.

CAUTION Beware of electrostatic discharge when touching objects inside the logger housing.

CAUTION Make sure that the vent tube of the pressure sensor is not blocked or bent during transportation.

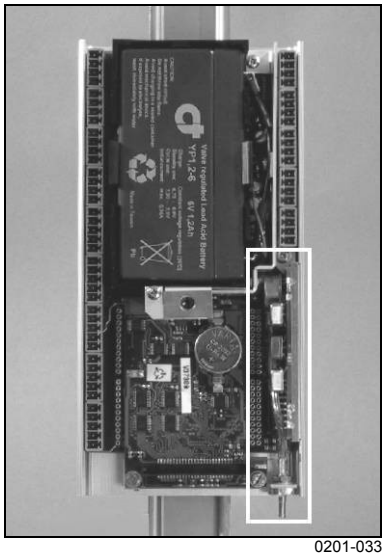


Figure 64 PMT16A Location on the Logger

Installing Wind Sensor

Before installing the sensor itself, you have to mount the wind sensor mast to the upper base of the tube. After you have installed the mast, you can mount the wind sensor on top of it. For more information, see Figure 40 on page 56.

Aligning Wind Vane

Using winddircal0 Command

1. Turn the nose (1) of the vane to a known point of compass (e.g. north).
2. Give command **winddircal0** with the known direction reading (e.g. **winddircal0 360**. This will set the current direction to the north, 360 degrees).

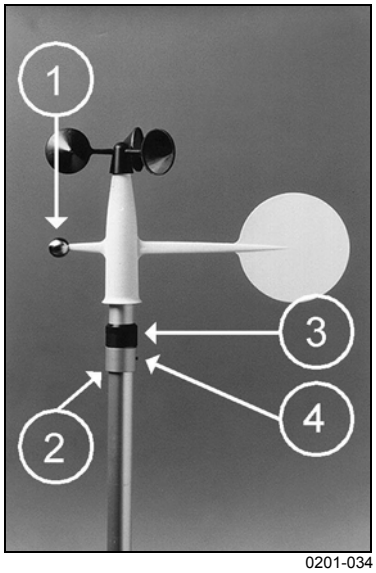


Figure 65 Aligning the Wind Vane

Using Compass and Reference Point

With the MAWS running, monitor the instant wind speed in the reports sent through serial line.

1. The wind sensor cable must be connected both to the sensor and to the Wind connector.
2. The mounting piece (2) must be placed on top of the upper tube and the sensor must be attached to the mounting piece with the plastic collar (3).
3. Choose a known wind direction reference point on the horizon with the help of a compass.
4. Point the nose of the vane at the reference point.
5. Hold the vane in position and slowly rotate the mounting piece until wind direction shows proper value.
6. Secure the mounting piece to the mast by tightening the mounting screw (4).

Installing Air Temperature and Relative Humidity Sensor

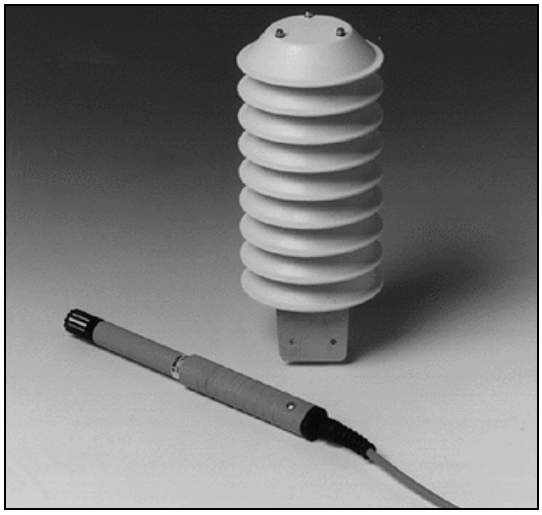


Figure 66 QMH101 Probe and the Radiation Shield

Install the QMH101 Temperature and Relative Humidity Sensor in the following way:

1. Install the radiation shield with the support on the mounting arm using the two screws.
2. Slide the temperature and humidity probe into the shield.
3. Tighten the fastening ring.
4. Guide the sensor cable through the sensor arm opening.
5. Connect the signal cable to the upper base plate of the tube. See Table 11 on page 72.

Installing Rain Gauges

QMR101

QMR101 is usually installed on the same sensor arm with the temperature and humidity probe. QMR101 should be attached to a sensor arm in the following way:

1. Attach the mounting plates (1) to the sensor (2), if not already in place.

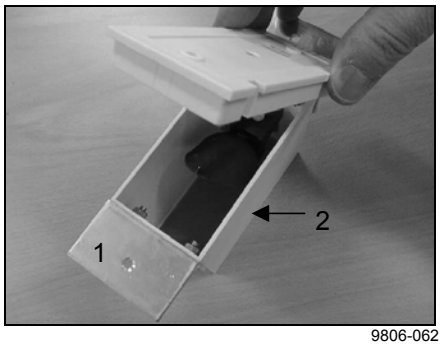


Figure 67 Mounting Plates Attachment

2. Attach the rain gauge (1) to the arm with the screws (2) provided with the rain gauge.

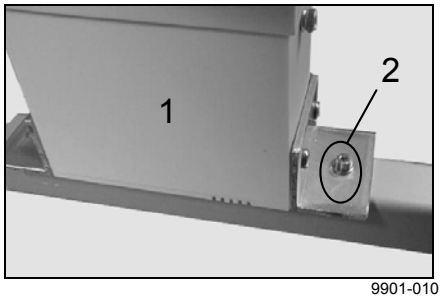


Figure 68 Rain Gauge Attachment

QMR102

Due to the low weight of the rain gauge, it must be mounted securely. QMR102 can be installed either using a specific stand RG35003 or on the ground when it is attached to a properly anchored RGB1 base plate with provided studs. As well, the gauge can be mounted via the three holes in the base, for example, to a paving slab. You should use rawl plugs and standard steel studs for this purpose as they provide a means of leveling the rain gauge.

Installing on the Stand RG35003

To install the gauge on the stand, follow the procedure below:

1. Attach the stand (3) to a concrete foundation with the bolts (5). See Figure 69 on page 77.

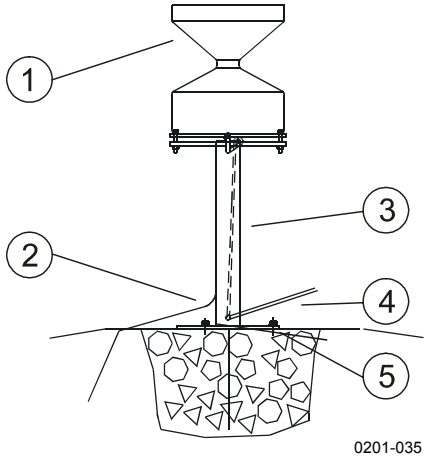


Figure 69 Rain Gauge Installed On a Stand

2. Mount the gauge (1) to the upper plate of the stand using the provided hardware. For an example, see Figure 70 below.

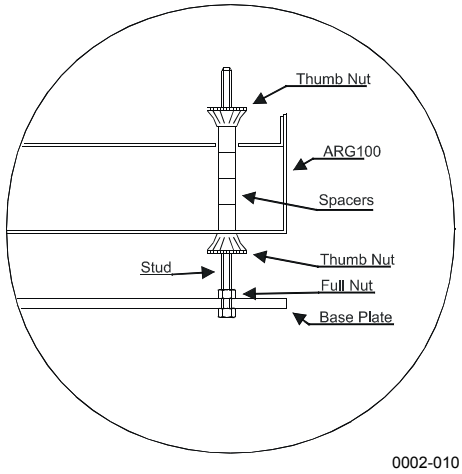


Figure 70 Rain Gauge Attachment

3. Connect the grounding cable (2).
4. Connect the signal cable (4) to MAWS. For the cabling, see Table 11 on page 72.
5. Continue from section Finalizing the Installation on page 79.

Installing on a RGB1 Base Plate

1. Use the RGB1 base plate as instructed in the provided data sheet.
2. Connect the signal cable (4) to MAWS. For the cabling, see Table 11 on page 72.
3. Continue from section Finalizing the Installation on page 79.

NOTE	The base plate may be mounted to hard surfaces like concrete by replacing the pegs with screws and rawl plugs. For temporary mounting on hard surfaces use heavy weights on the four corners of the base plate. The height of the weights should be kept as low as possible to cause the minimum interference with the aerodynamics of the rain gauge.

Installing on a Pedestal

1. Drill out three holes in the base to the 6.5 mm in diameter and clean off burr. For details, see Figure 71 below.
2. For the pegs, drill out a hole in the each corner of the pedestal plate. Clean off burr.

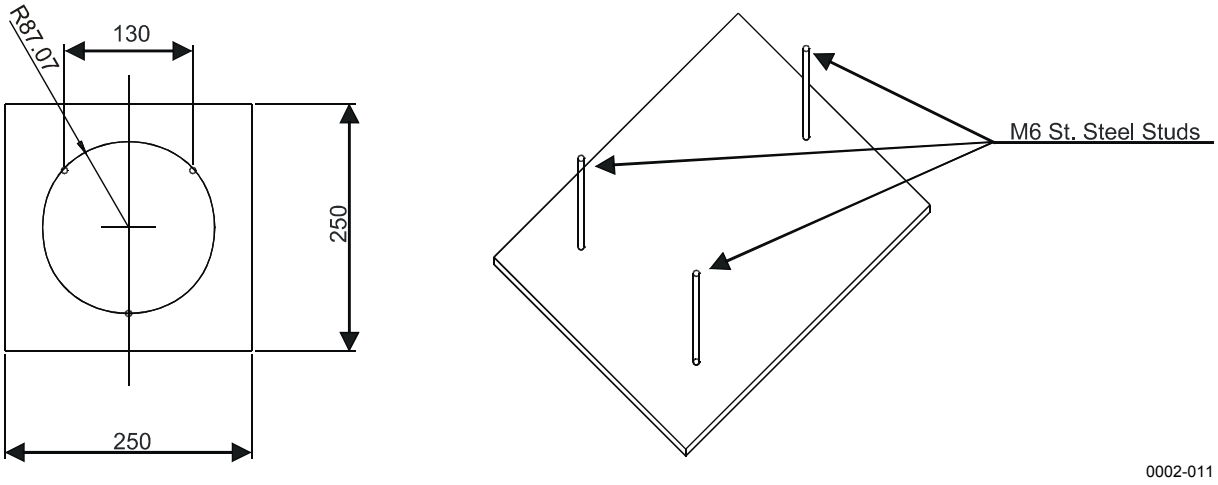


Figure 71 Rain Gauge Pedestal Plate Dimensions

3. Place the pedestal plate with rain gauge assembly on the ground using the pegs supplied. If force is needed, then remove the rain gauge first. See Figure 72 on page 79.

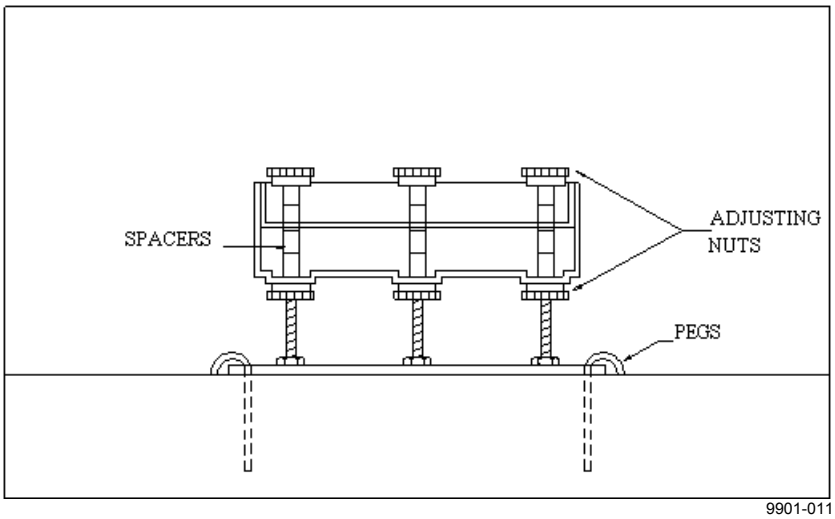


Figure 72 Assembling QMR102 on the Ground with Pedestal Plate

4. Connect the signal cable (4) to MAWS. For the cabling, see Table 11 on page 72.
5. Continue from section Finalizing the Installation below

Finalizing the Installation

Finalize the installation as described in the following steps:

1. To be able to release the rain gauge's tipping bucket mechanism, and adjust the level, first remove the funnel from its base by unscrewing the three plastic thumbscrews (1). See Figure 73 below.

Figure 73 Funnel Fixing Screw

2. Remove the piece of foam (2) from under the bucket mechanism. This foam may be saved and used whenever the rain gauge is moved. See Figure 74 on page 80.

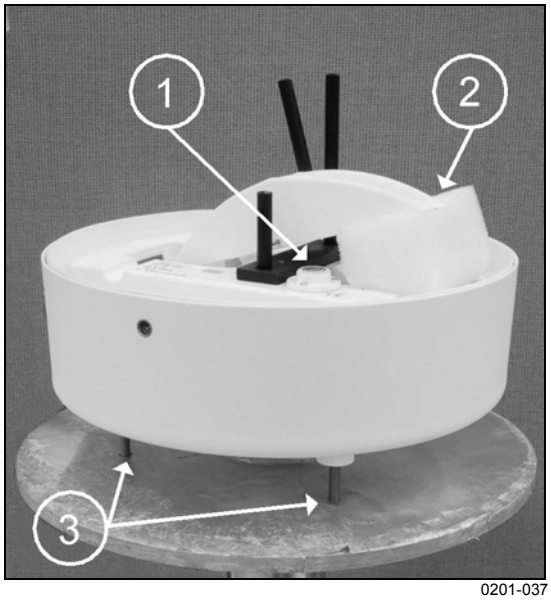


Figure 74 QMR102 Adjustment and the Foam Location

3. It is important to ensure that the rim of the rain gauge is leveled precisely. Failure to do this will result in a systematic error. Use a spirit level (1) and adjust with the fixing screws (3). See Figure 74 above.

4. The cable length can be shortened or lengthened as required. If the cable is lengthened, please ensure a good quality environmental connector, or a heatshrink joint (see Figure 75 below). Extension cables used must be of a similar specification.

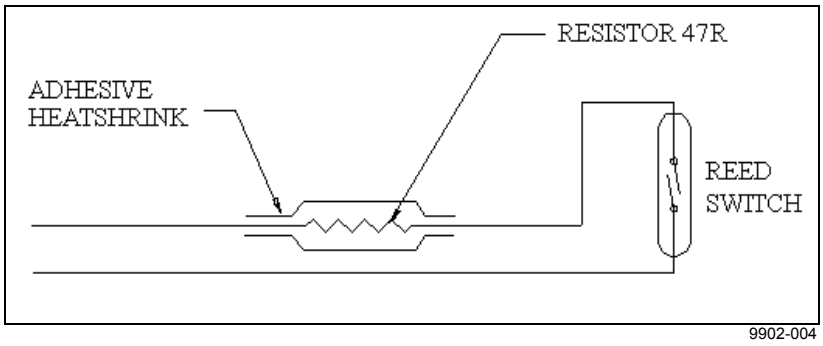


Figure 75 Wiring Diagram of QMR102

NOTE	When using QMR102, the shield must be connected to the ground.

Installing Solar Radiation Sensors

NOTE	Preferred orientation for the solar radiation sensors is such that no shadow is cast on the solar radiation sensors during any time of the day. In the northern hemisphere, this implies that the solar radiation sensors should be south of the mast.

QMS101/QMS102

The pyranometer (QMS101 or QMS102) can be installed on a sensor arm as follows:

1. Attach the pyranometer (2) to the sensor arm (1) using the bolts (3) provided. For the explanation of the numbers, see Figure 76 below.
2. Lead the cable (4) through the sensor arm (5). Guide the sensor cable through the sensor arm opening (6).
3. Finally, connect the signal cable to the connector at the lower base of the tube. For more information, see section Connecting Cables on page 71.

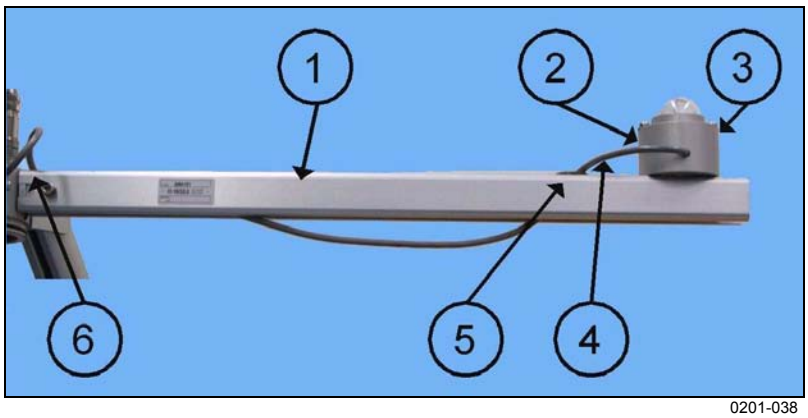


Figure 76 Installing QMS101 or QMS102 Pyranometer on Sensor Arm

QMN101

It is recommended to install the sensor at least 1.5 meters above the surface in order to avoid shading effects and to promote spatial averaging. Install the sensor as follows:

1. Slide the mounting piece (1) to the sensor arm (2). Tighten with the screws. For the numbers, see Figure 77 below.
2. Attach the radiometer (3) to the extension arm (4). Attach the sensor's extension arm (4) to the mounting piece (1). Tighten with the screws.
3. Lead the cable (5) through the sensor arm (1). Guide the sensor cable through the sensor arm opening (6).
4. Finally, connect the signal cable to the connector at the lower base of the tube. For more information, see section Connecting Cables on page 71.

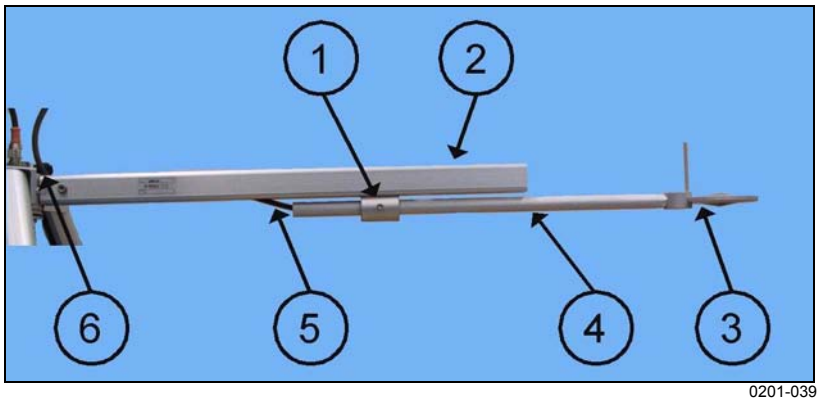


Figure 77 Installing QMN101 Net Radiometer

Installing Soil Temperature Sensors

QMT103

QMT103 soil/water temperature sensor has a ready-made 5 m cable and the connector. The connector L at the lower base of the tube is reserved for the first sensor. The connectors M and O can also be used for additional soil/water temperature sensor. For more information, see Table 10 on page 71.

QMT107

During a typical installation, QMT107 probe is pressed into pre-formed holes, but they can also be placed into excavated holes that are then filled. On hard or rocky ground, a pilot hole is pre-formed with an auger rod. Drill a hole according to the following procedure:

1. Choose a desired location for the probe. Assure that probe holes are located within cable length of the logging unit.
2. Drill a hole into the ground with the auger held as straight as possible. After you have drilled about 20 cm, extract the auger from the hole.

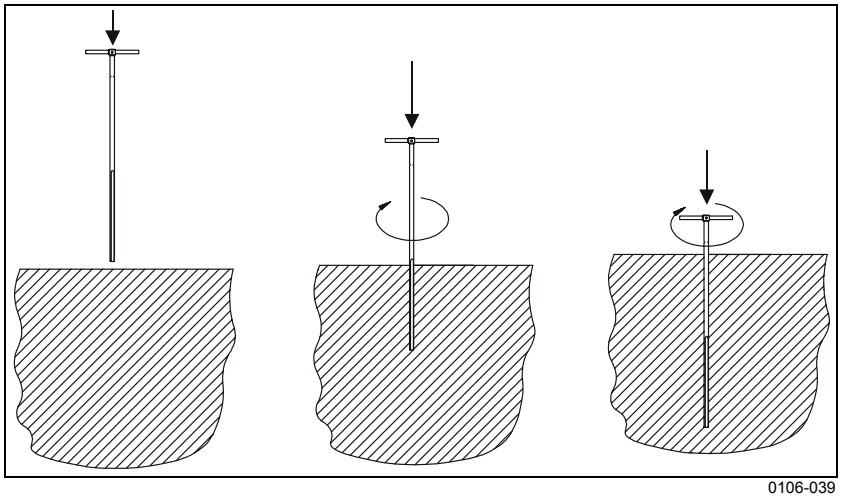


Figure 78 Drilling Procedure

CAUTION Do not use a hammer to pound the auger into ground.

3. Remove soil from the auger, for example with a screwdriver. Refer to Figure 79 below.

WARNING Do not use fingers to clean the auger. The edges are sharp.

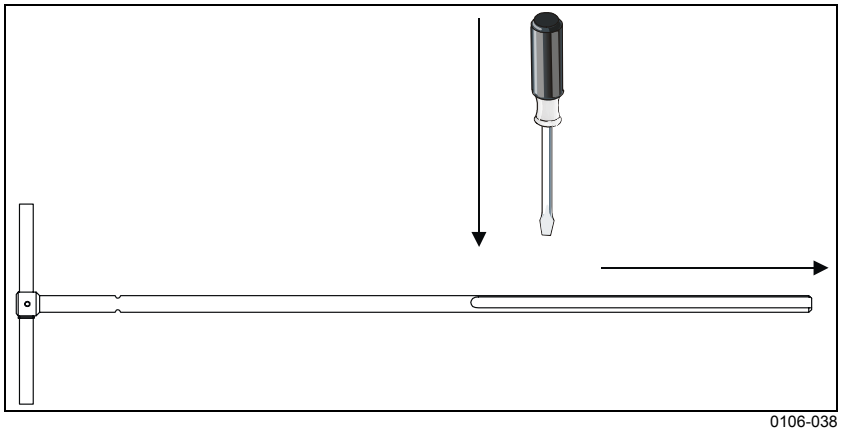


Figure 79 Cleaning the Auger with a Screwdriver

4. Repeat steps 2 and 3 until you have reached the desired depth. The maximum drilling depth is approximately 115 cm.

Insert the probe into the hole according to the following procedure:

1. Remove the auger from the hole.
2. Insert the probe into the hole and press it down as deep as possible by hand. Insert the probe deep enough into the soil so that the soil/air boundary is at the ground level line. The ground level line is marked on the sensor (see Figure 80 below).

CAUTION Never use a hammer or other instrument directly on the head of a probe. If too much force is applied to the probe, damage to the electronics inside may result.

NOTE Any delay in inserting the probe into the drilled hole may allow moisture to swell the hole sides, or fill the hole with water.

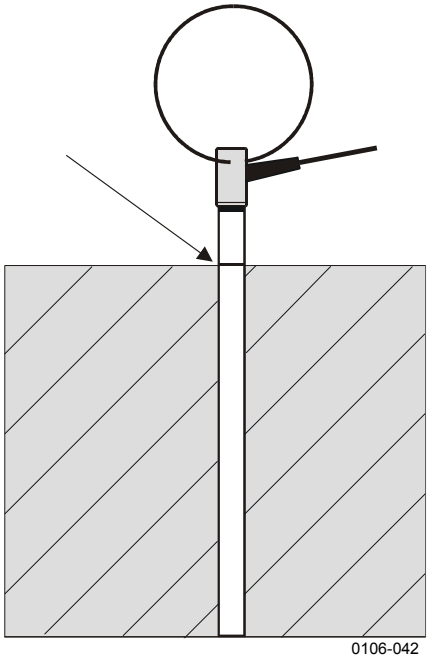


Figure 80 Soil Temperature Probe Inserted Correctly, Arrow Pointing to Ground Level Line

CAUTION	DO NOT drive or press probes directly into soil of unknown composition. DO NOT bend or flex probes during insertion or extraction. DO NOT attach unapproved electrical devices or test equipment to the probe. DO make a pilot hole prior to each probe insertion, unless the soil consists of homogenous, loose sand. DO inspect and clean the probe connector prior to each use. Note that probe warranty is void if a hammer or unapproved tool is used to drive the probe into the soil.

3. Finally, connect the signal cable to the connector at the lower base of the tube. For more information, see section Connecting Cables on page 71.

Installing Soil Moisture Sensor

To install the ML2x sensor, follow the procedure below:

1. The sensor can either be inserted or buried into the soil as shown in Figure 81 below and Figure 82 on page 86.

Figure 81 ML2x Soil Moisture Sensor

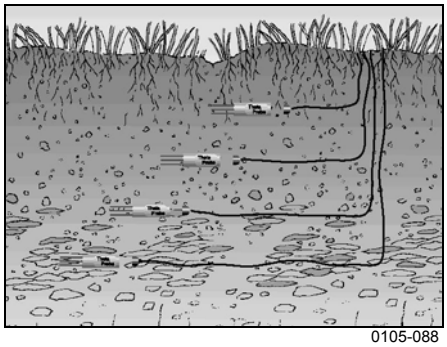


Figure 82 Buried ML2x Sensors

2. Pull the sensor cable close to the equipment enclosure. Cut the cable to a proper length. Thread the cable through the connector parts in the indicated order 1-2-3-4. See Figure 56 on page 66.
3. Strip the sensor cable wires and connect them to connector terminals according to Table 12 below. Make sure that the spring of lead-in connector is in good contact with the shield. Assemble the connector.

Table 12 Cable Pins of ML2x Soil Moisture Sensor

Pin Number	Wire Color	Signal
1	Red	Supply, +
2	Yellow	Signal HI
3	Blue	Supply, -
4	Green	Signal LO

4. Finally, connect the signal cable to the connector at the lower base of the tube. For more information, see section Connecting Cables on page 71.

Installing Water Level Sensors

QMV101/QMV102

For the location of the QMV101/QMV102 water level sensor, see section Water Level on page 51.

QMV sensors have a ready-made cable and a connector. Connect the signal cable to an available connector at the bottom of the tube (see section Connecting Cables on page 71).

Installing Leaf Wetness Sensor

QLW101 Leaf Wetness Sensor is delivered with an installation hardware kit and a 5-meter long sensor cable.

You may test the sensor before you install it. The instructions below provide a description of the suggested quick test procedure.

1. Connect the signal cable to the connector at the lower base of the tube. For more information, see section Connecting Cables on page 71.
2. Configure the sensor. See the MAWS Lizard User's Guide for instructions.
3. Drop or spray water onto the sensor and make sure the reading changes.

On the Wooden Surface

To mount the sensor against a wooden surface, secure the sensor to the surface using wood screws (see Figure 83 below).

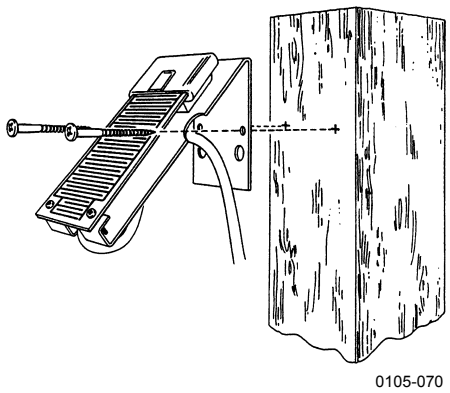


Figure 83 Mounting QLW101 to a Wooden Surface

To a Pole Mast

You can mount the sensor to a mast with an outside diameter between 25 and 31 mm. Secure the sensor to the pipe using the U-bolt, flat washers, and hex nuts as shown in Figure 84 on page 88. Use a right size wrench or adjustable wrench to tighten the hex nuts.

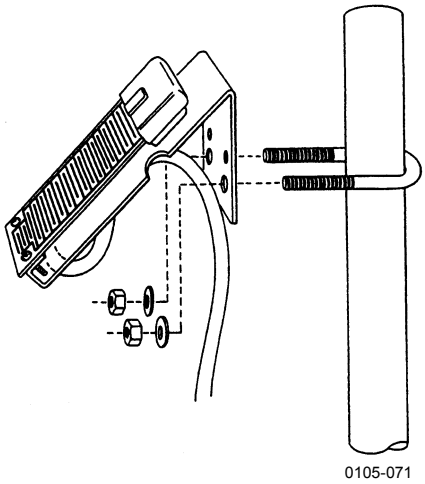


Figure 84 Mounting QLW101 to a Pole

To the Sensor Arm

For installation to the sensor arm, use the provided hexagon bolts and lock washers. Tighten the hex nuts with a 6 mm Allen key. See Figure 85 below.

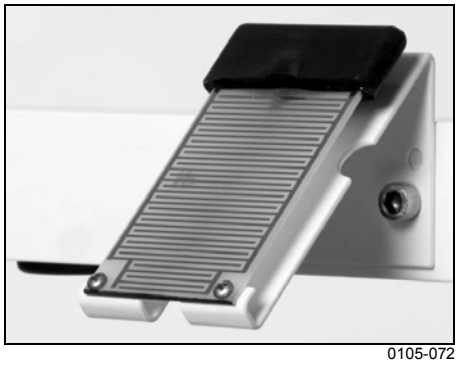


Figure 85 QLW101 Installed on Sensor Arm

Finalizing the Installation

1. Install the sensor as shown in Figure 83 on page 87, in Figure 84 above, or in Figure 85 above.
2. Pull the sensor cable close to the tube's lower base. Cut the cable to a proper length. Thread the cable through the connector parts in the indicated order 1-2-3-4. See Figure 56 on page 66.
3. Strip the sensor cable wires and connect them to connector terminals according to Table 13 on page 89. Assemble the connector.

Table 13 Cable Pins of QLW101 Leaf Wetness Sensor

Pin Number	Wire Color	Signal
1	Red	Supply, +
2	White	Signal HI
3	Black (two wires)	Supply, -

4. Loosen and remove two hand screws beneath the tube. Slide the tube down to expose the logger (see Figure 34 on page 53).
5. Remove a connector from the input channel. Exact channel depends on your configuration. Insert adapter QLA001 to the channel and place the connector on top of it.
6. Connect the signal cable to an available connector at the bottom of the tube (see section Connecting Cables on page 71).

Figure 86 Adapter Installed to Connector

Installing Fuel Moisture Sensor

You should install the QFM101 sensor 30 cm above the forest floor and orient the sensor parallel to the ground.

CAUTION It is important to keep the wooden dowel part of the sensor clean. Avoid touching the dowel with bare hands. Any contact with grease or oil will prevent the sensor from exchanging moisture and will make the calibration invalid.

QFM101 uses two analog channels of the logger: one for the temperature measurement and another for the moisture measurement. Moisture is measured via one of the channels CH1 to CH3. You should connect the sensor cable to the appropriate channel. Temperature is measured with one of the channels CH4 to CH7 and therefore you should modify the wiring as instructed below.

The mounting bracket (1 in Figure 87 below) is not included in the sensor delivery. A rubber-lined ring clamp (3) and the screw (4) are included with the sensor in the package. To install the sensor, follow the procedure below:

1. Slide the ring clamp (3) onto the sensor body (2) and connect the cable to the sensor.
2. Turn the sensor so that the two wire loops imbedded in the wooden dowel will be horizontal. That is, the wires must be on the sides of the sensor, not the top and bottom. Tighten the clamp with the screw (4).

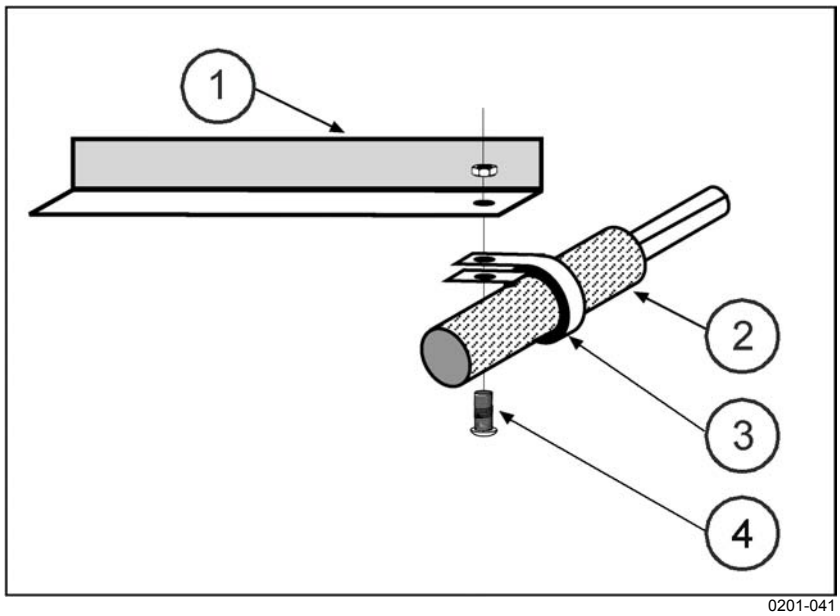


Figure 87 Installing the Sensor with the Clamp

3. Secure the slack in the cable to the tower leg or the sensor bracket with a cable tie.
4. Loosen and remove two hand screws beneath the tube. Slide the tube down to expose the logger (see Figure 34 on page 53).
5. Select one of the analog channels, CH1 ... CH3, and place the connector to the selected input channel at the logger. The exact channel depends on your configuration.
6. Remove the connector from the selected temperature measurement channel, that is, one of the channels CH4 ... CH7. The removed cables and their connector are not needed. Insert adapter QLA005 to the channel and place the connector on top of it.

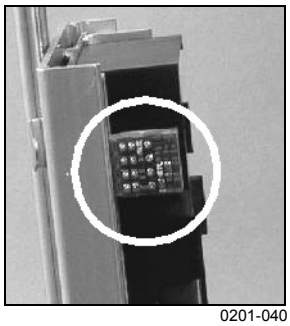


Figure 88 Adapter Installed to Connector

7. Modify the wiring according to the Table 14 below.

Table 14 Modified Wiring with QFM101

Wire Color	Standard Connection Pin at the Logger	Modified Connection Pin at the Logger
Red	Not connected.	**Connect the wire to the terminal C of the selected temperature measurement channel (CH4 ... CH7).**
Brown	E	Leave as is. This wire is used for the moisture measurement.
White	H	Leave as is. This wire is used for the moisture measurement.
Black	L	**Move the wire to the terminal E of the selected temperature channel (CH4 ... CH7).**
Blue	C	Leave as is. This wire is used for the moisture measurement.

8. Connect the signal cable to the connector of the modified input channel at the bottom of the tube (see section Connecting Cables on page 71).

Installing Communication Devices

Installing Communication Modules

Modules can be attached on the circuit board to provide communication channels for MAWS. For the placement of the modules, see Figure 89 on page 92. The modules can simply be pushed on the connector blocks MOD1 and/or MOD2. Module options include DSU232, DSI485A, DSI486, and DMX501. By default, the modules are installed as described in Table 15 on page 92.

Table 15 Default Configuration for Communication Modules

Module	Connector Block	Port
DSU232	MOD1	COM1
DSI485A / DSI486	MOD2	COM2
DMX501	MOD2	COM2

CAUTION When inserting, be careful not to bend the connector pins.

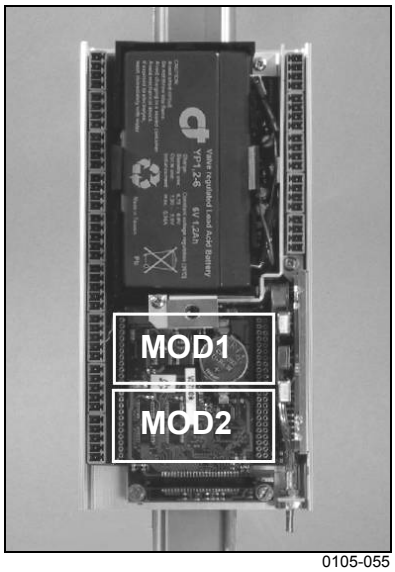


Figure 89 Module Placement

For the principal wiring diagrams of the modules, see section Wiring Diagrams on page 163.

Installing SATELLINE 3AS Radio Modem

The radio modem SATELLINE 3AS comes with a ready-made cable (approx. 0.5 m) and a special weatherproof enclosure.

The DSU232 communication module should be used to provide an additional RS232 output for the radio modem, leaving the standard COM port (COM0) free for maintenance purposes.

For powering of the radio modem, you need a mains power supply or a mains/solar power supply with backup batteries. The standard solar panel can not supply sufficient power for the radio modem. In

addition, you have to change the wiring to be able to use the COM1 port and the provided cable for powering the radio modem from the External DC (+ExtDC) of the logger.

1. Remove the logger's cover and install the DSU232 communication module to the MOD1 location. See Figure 89 on page 92.
2. Reassemble the logger's cover.
3. Install an additional sensor arm with radio modem fixtures to MAWS. See Figure 42 on page 57 and Figure 43 on page 57.
4. Install the radio modem to the fixture. See Figure 90 below.

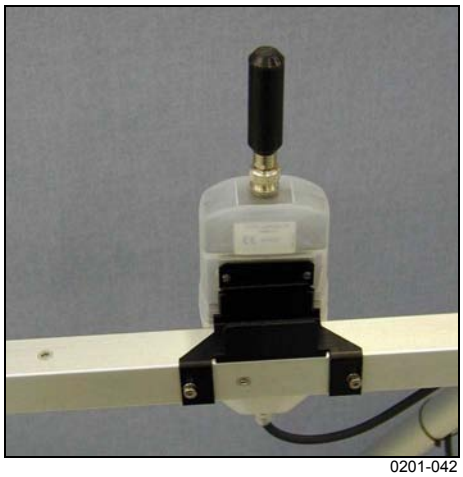


Figure 90 Radio Modem and the Fixture

5. Disconnect the wires Red and Brown from the COM1 connector (2). Connect the Red wire to GND and the Brown wire to +ExtDC terminal of the Power connector (1). See Figure 91 on page 94.

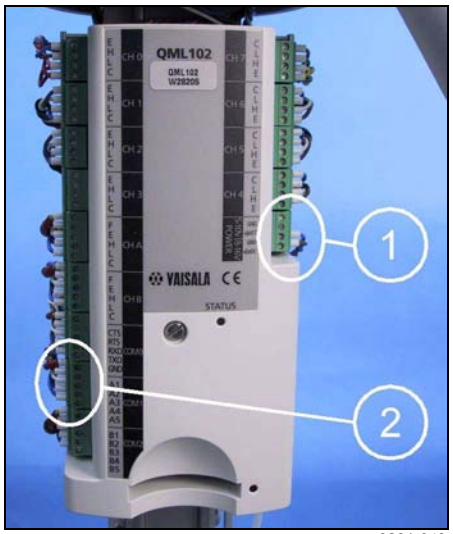


Figure 91 Wire Modifications with Radio Modem

6. Connect the ready-made radio modem's cable to the port COM1 in the lower base of the tube.

NOTE	It is recommended to label these modifications so that no other equipment is connected to COM1 by mistake. The 12 VDC voltage may damage some equipment.

7. Configure the radio modem with MAWS Lizard. For detailed information, refer to Technical Reference listed in Table 2 on page 15.

Installing Accessories

External Memory Expansion Board

1. Open the screw on the logger's cover and remove the cover.
2. Remove the communication modules (if any) from the circuit board.

CAUTION	Be careful not to bend the connector pins.

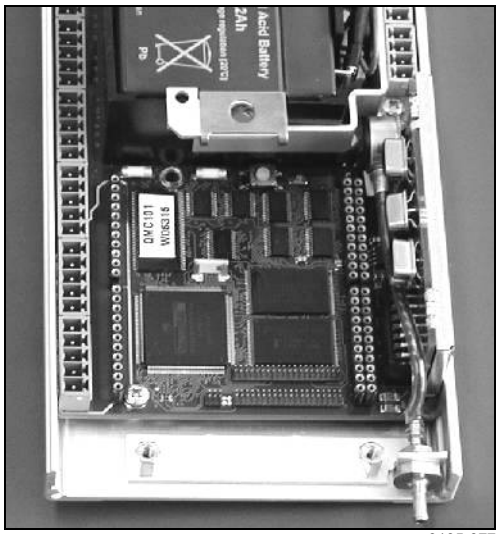


Figure 92 Communication Modules Removed

3. Align the pins on the memory board with the slots on the logger and push the board back into its place.
4. Secure the board with a lock bar (number 2 in Figure 93 below) using the screw 1 and a long screw at the rear side of the logger. Attach also the screws 3 and 4.

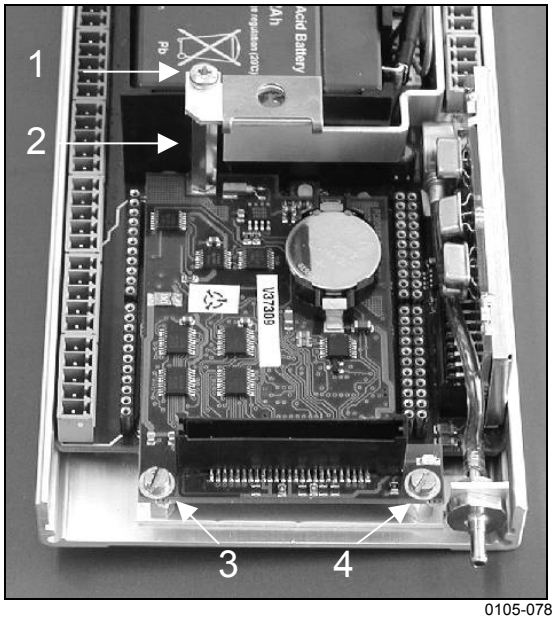


Figure 93 External Memory Expansion Board Installed

Installing Software

Installing Embedded Software

The embedded software on the logger is normally installed at the factory. For the instructions on installing a new, updated version, see the Software Loading Technical Notice listed in Table 2 on page 15.

Installing MAWS Terminal

For the instructions on installing the MAWS Terminal software to a PC, see the MAWS Lizard User's Guide listed in Table 2 on page 15.

Installing Lizard

For the instructions on installing the MAWS Lizard setup software to a PC, see the User's Guide listed in Table 2 on page 15.

Disassembly of MAWS201 for Transportation

1. Disconnect the power as follows:
   a. For short storage periods, set the MAWS into low power consumption mode by giving the command **SLEEP**.
   b. For long periods (over one month), disconnect the battery. First, open the hand screws that hold the tube in its place. Open logger housing. Detach red wire from the + terminal. Attach logger housing, lift the tube up and secure it with the hand screws.
2. Remove the cables from the upper and lower base connectors.
3. Detach sensor arm(s). Insert the screws back in their places for safekeeping.
4. Detach upper tube. Insert the screw back in its place for safekeeping.
5. Remove wind sensor by opening the plastic collar. Detach wind cable.
6. Tilt the solar panel so that it is parallel to the tripod leg. Cover the panel by an opaque cover or other material before electrical connections to the modules or other system components are handled.
7. Loosen the Locking screw, put the legs together and tighten the locking screw again.

WARNING	Be careful when drawing together the tripod legs. See that there are no power lines or other obstacles above the mast (and wind sensor).

QMT107 Probe Extraction

Follow the procedure below to extract the probe. See Figure 94 on page 98):

1. Set a piece of wood or similar close to the sensor.
2. Pass the auger rod through the wire loop at the top of the probe.
3. Make the auger handle rest onto the piece of wood.
4. Lift the probe.

NOTE	Small, gentle strokes are essential for extracting the probe.

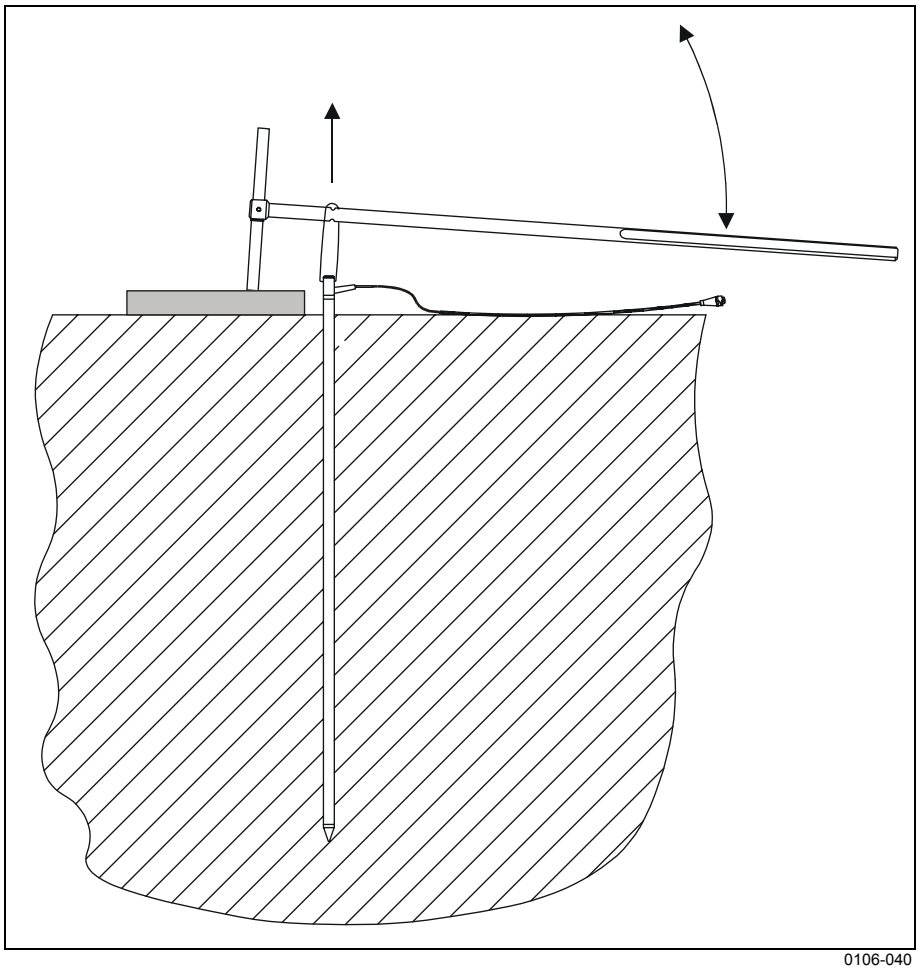


Figure 94 Probe Extraction

CAUTION	If too much force is applied, damage to the electronics of the probe may result.

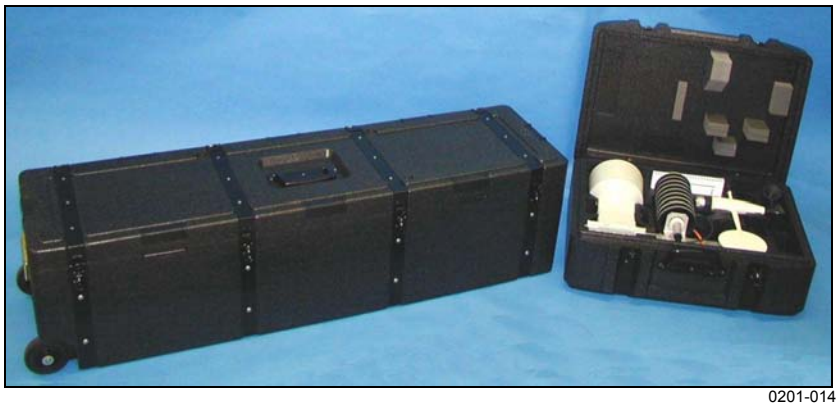
Packing Instructions

For easy packing of the MAWS201 weather station, carry case sets are available as options, see section Product Nomenclature on page 20. For an example, see Figure 95 below and Figure 96 below.

Pack the sensors in the smaller carry case. Pack the tripod, upper tube, sensor arms, and accessories in the bag or bigger carry case.

0201-013

Figure 95 QMM110 Carry Case Set



0201-014

Figure 96 QMM120 Carry Case Set

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CHAPTER 4
OPERATION

This chapter provides the instructions for taking MAWS Automatic Weather Station into use when all the equipment has been assembled and installed.

Operation Principle

MAWS works based on a so-called setup. Setup is a program that tells MAWS what to measure, log, calculate, and report. Measured data is stored in the daily log files that can be downloaded to a PC and viewed using the MAWS Terminal software.

The Basic setup has been loaded in the MAWS program memory already at the factory. This allows you to just connect the sensors, connect communication lines, and supply power to MAWS. Then your station will start operating: making measurements, doing calculations and sending report(s).

On the MAWS CD-ROM, delivered to you with the system, you will find several setup examples, named as DEMOx. The delivered setups will suit typical needs, but you may want to make changes to them. For reconfiguring the setup files or making totally new ones, refer to the MAWS Lizard software User's Guide listed in Table 2 on page 15.

Taking MAWS into Use

Aligning the MAWS201 Station

Figure 97 below gives a suggestion of positioning the weather station on the Northern Hemisphere. The solar panel should face south, and the temperature and humidity sensors be on the northern side of the MAWS.

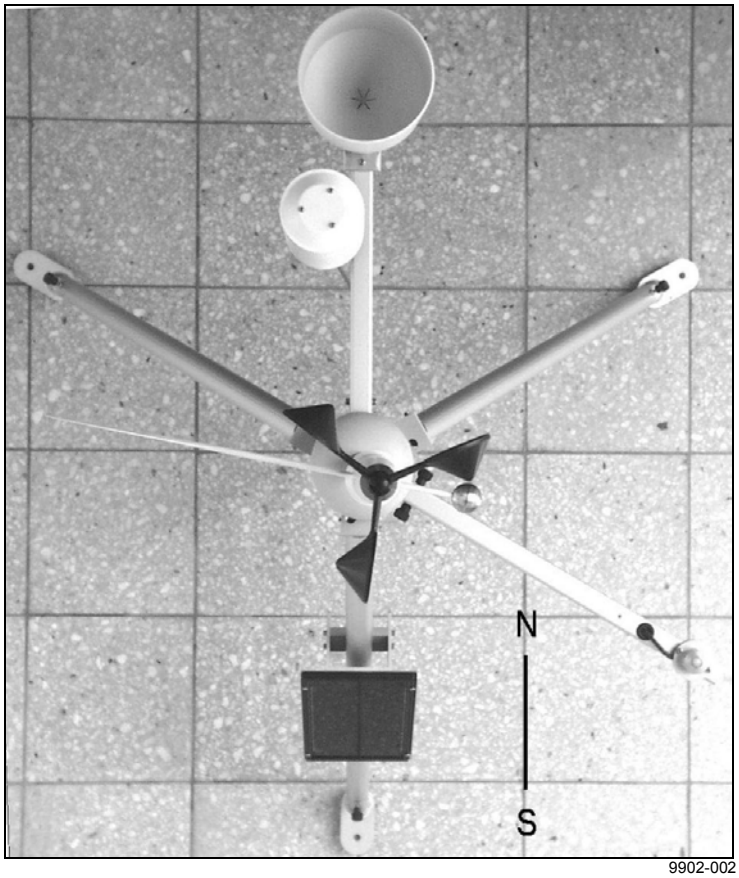


Figure 97 Aligning MAWS201 on the Northern Hemisphere

Quick Start Instructions

The quick start instructions in Table 16 below are based on the following assumptions:

- You will use a default setup already loaded in MAWS.
- You have already assembled the MAWS station.

Table 16 Quick Start Instructions

Step	Action	Detailed Instruction
1.	Connect power to MAWS.	You can use the AC power supply or the solar panel.
2.	Establish terminal connection with MAWS.	See section Establishing Terminal Connection on page 104.
3.	Start the MAWS Terminal software.	See section MAWS Terminal Main Window on page 106.
4.	Make station-dependent settings for MAWS.	See section Modifying Station Settings on page 113.
5.	Test the setup.	With the chosen setup loaded into MAWS (see section MAWS Configuration File on page 116), check that you start receiving reports and that logging begins.

When taking MAWS into use for the first time or after connecting the battery, make sure that the station dependent settings are correct, see section Modifying Station Settings on page 113. For more information about the commands, see Table 25 on page 129.

Establishing Terminal Connection

To connect your computer to a MAWS serial port, proceed as follows:

1. Connect the provided terminal cable (QMZ101) to the COM0 connector in the bottom plate of the tube and to an available COM port on your PC. See Figure 98 below.

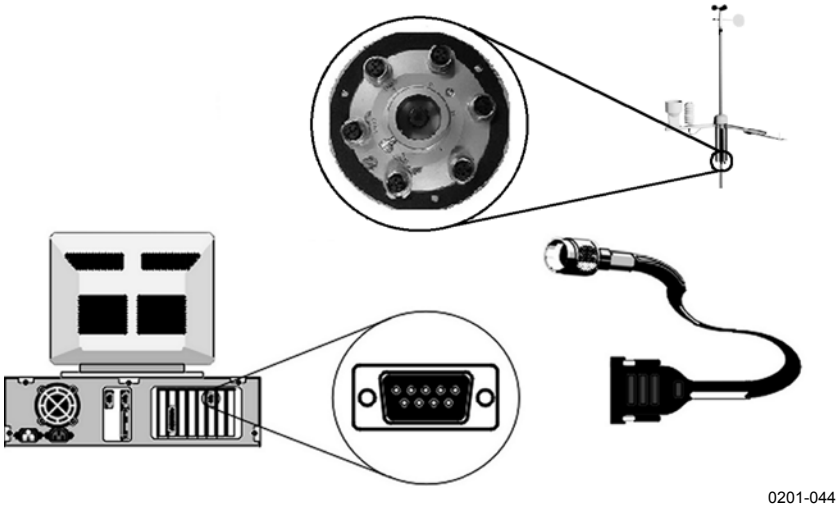


Figure 98 Connecting the Terminal Cable

2. Start MAWS Terminal program on your PC, as instructed in section Using MAWS Terminal Software on page 105.
3. Set communication parameters: 9600, N, 8, 1.For more information, see section Opening MAWS Service Connection on page 110.
4. Give the command **open** (if the connection is not already open). For more information, see section Giving Commands on page 112.

NOTE	The command **open** is not echoed on the screen.

Figure 99 on page 105 shows the pin order for the terminal connector.

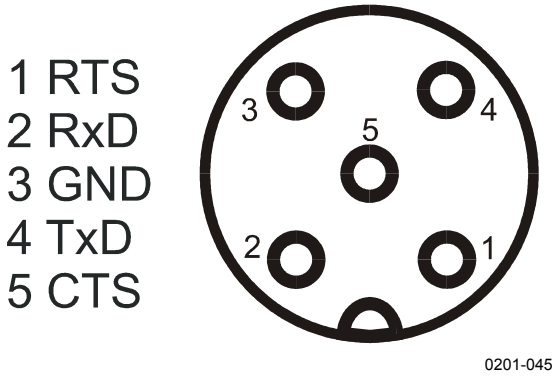


Figure 99 COM0 Pins for the Terminal Connector

Using MAWS Terminal Software

Selecting the Language

When you start MAWS Terminal for the first time, you will be asked to select the language you would like to use. The **Select Language** window, presented in Figure 100 below, will appear. Select the desired language and click **OK**.

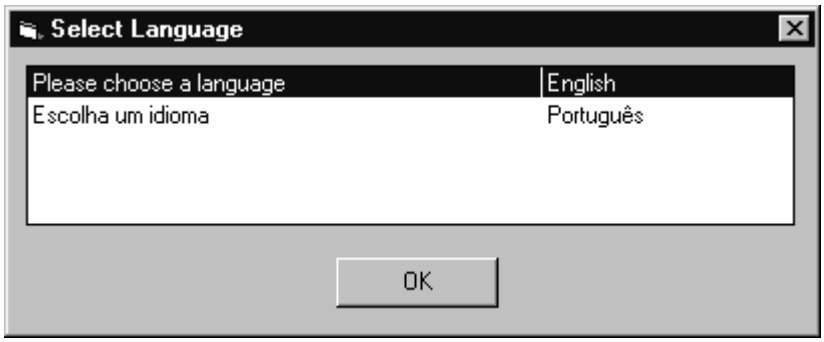


Figure 100 Select Language Window

The **Select Language** window will only appear when MAWS Terminal is started for the first time. To change the language later, choose **Preferences** from the **Settings** menu, and then select the **Language** tab. In the **Language** tab, select the desired language from the **Available Languages** box and click **OK**.

MAWS Terminal Main Window

After selecting the language, or when you later start the MAWS Terminal software by clicking the MAWS Terminal icon on your desktop, the following window appears.

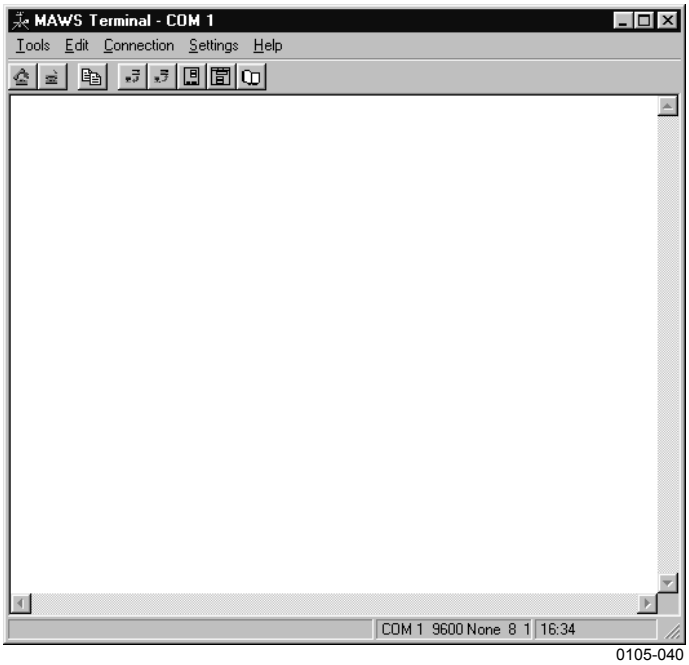


Figure 101 MAWS Terminal Main Window

When the service connection is closed, the messages and reports appear on the main window as shown in Figure 102 on page 107. Some values are shown as slashes, because they will later be calculated from the measured values.

NOTE	Report type and appearance shown in Figure 102 on page 107 depend on your configuration.

When you have typed **open**, the service connection is open and you can communicate with MAWS with the commands described in Table 25 on page 129.

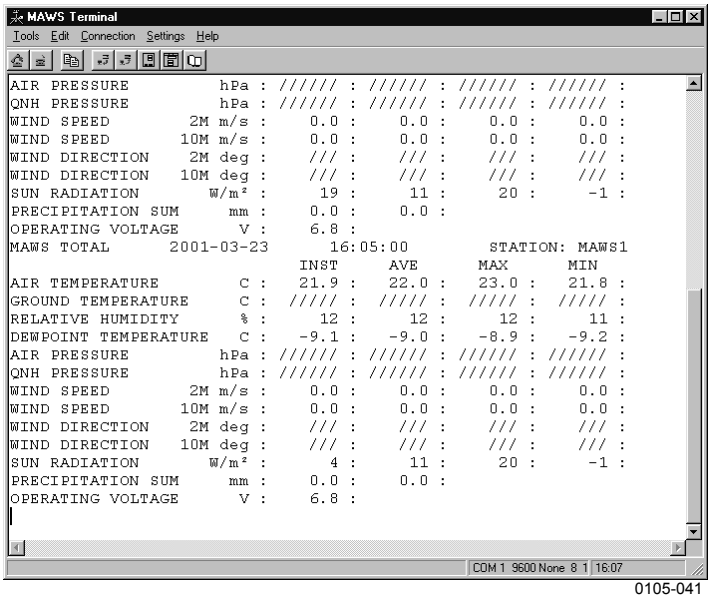
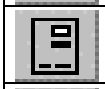
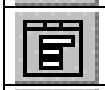
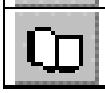


Figure 102 MAWS Terminal Showing Report

On the top of the main window, there is the MAWS Terminal toolbar. The toolbar is the quickest way to select functions.

Table 17 Description of the Toolbar

Icon	Function	Description
	Dial	Establish a connection to the MAWS station you have selected or to the modem you use for connecting to MAWS.
	Hangup	Close the connection to MAWS.
	Copy	Copy the selected text to Windows Clipboard.
	Download Log Files	Select the data log files you want to download and start downloading.
	Upload Configuration File	Select the new configuration file you want to upload and start the uploading.
	Set Station Settings	Define default settings for the MAWS station.
	Preferences	Define default settings for the download.
	Address Book	Open the address book for browsing communication settings.

You can exit MAWS Terminal by choosing the **Exit** option from the **Tools** menu.

Defining MAWS Terminal Settings

When you start the software for the first time, you need to define the settings you want to use during download. You can do this with **Settings** menu options.

Preferences Window

When you choose the **Preferences** option from the **Settings** menu, the **Preferences** window appears with the **Directories** tab.

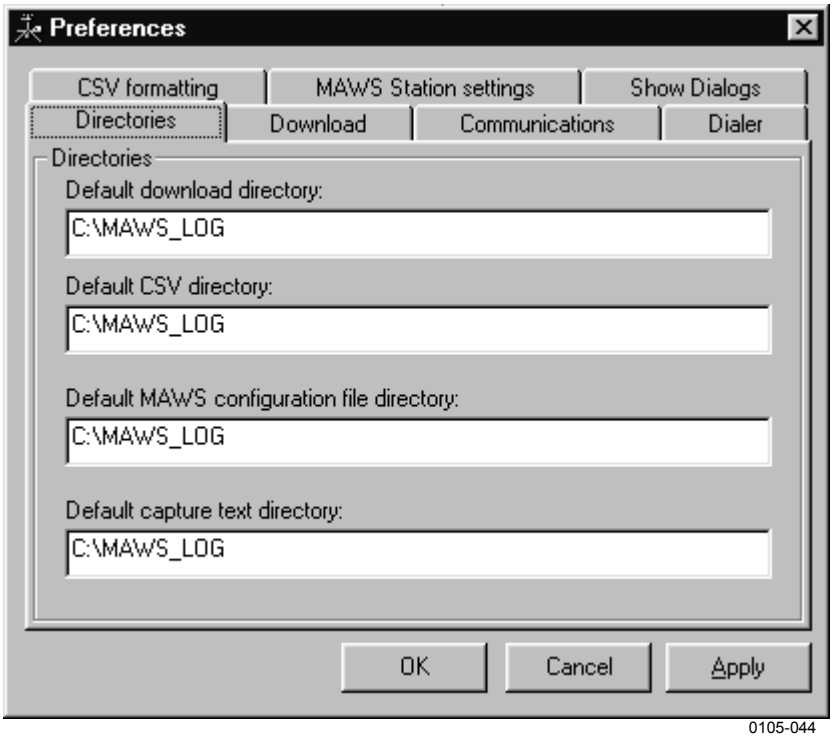


Figure 103 Directories Tab in Preferences Window

Table 18 Description of Preference Window Tabs

Tab	Description
Directories	On the Directories tab, you can define the directories you want to use for downloading and storing files. If you do not define a directory, the program stores all file types in C:\MAWS_LOG.
Download	On the Download tab, you can define the operations that the program runs automatically whenever you download data log files from MAWS.
Communications	On the Communications tab, you can define the communication port and related parameters. The default values are COM1, 9600, None, 8, None, 1, and buffer size 4 kB. Normally, you do not need to change the communication settings.
Dialer	If your system connects to MAWS via a modem, you can select how many times the modem tries to connect to MAWS if the first attempt is unsuccessful.
CSV formatting	This function is not implemented in the current version of MAWS Terminal.
MAWS Station settings	When you update the MAWS configuration file and the system is reset, MAWS spends a defined period checking the configuration. During this time, it does not respond to commands you send to the maintenance line. On this tab, you can define the length of the delay period.
Show Dialogs	On the Show Dialogs tab, you can select which dialogs you want displayed during the download process.
Language	On the Language tab, you can select the language used in the interface.

Address Book Window

When you choose the **Address Book** option from the **Settings** menu, the following window appears.

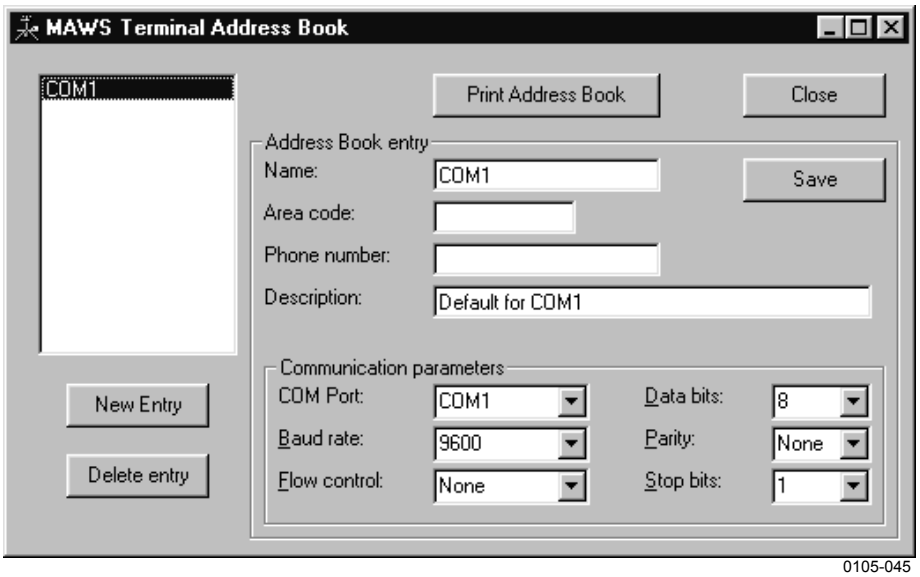


Figure 104 Address Book Window

In the **MAWS Terminal Address Book** window, you can define MAWS communication details. You can also define parameters for both directly connected stations and for stations that establish the connection via modem. You can add new entries and delete old ones.

Opening MAWS Service Connection

Before you can download files or upload the configuration file, you need to open the service connection to MAWS.

From the **Connection** menu, choose **Dial**. You can also click the **Dial** icon. The address book window appears.

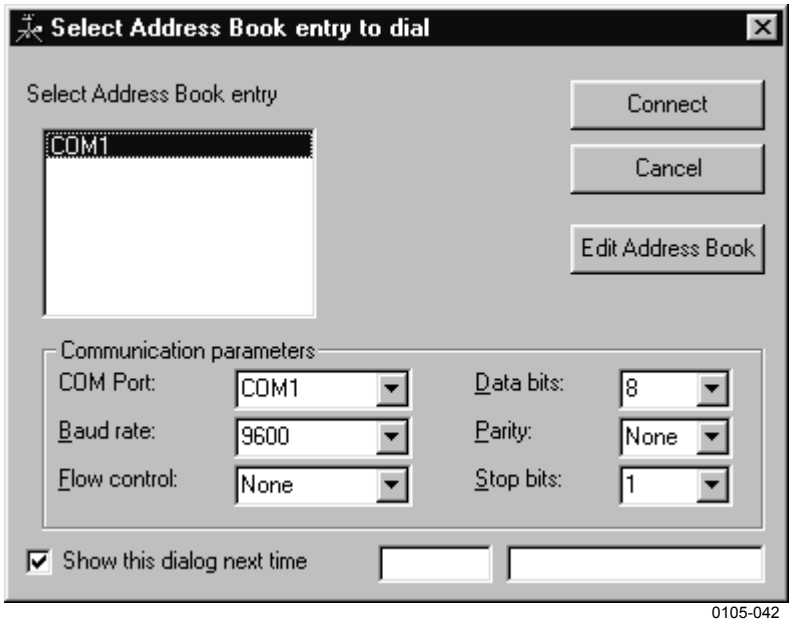


Figure 105 Address Book Window when Connecting to MAWS

In the address book window, select the port to which MAWS is connected and click **Connect**.

NOTE Before connecting, the **Password Entry** window opens, if you have set the user level in your MAWS. For more information on setting the user levels, see section Managing User Levels on page 115.

When the connection is opened, you will see the following text on your screen.

```
Service connection opened
/ >
```

NOTE The next time you are opening a service connection, the address book window is displayed. The program does not automatically connect you to the port you previously selected.
If you want that the address book window is not displayed every time you connect to MAWS, you can clear the **Show address book list before connecting** check box from the **Settings - Preferences - Show Dialogs**.

Giving Commands

When you have established the connection, you can use the commands (described in Table 25 on page 129) to communicate with MAWS. Commands are actually text sent from the PC or terminal to MAWS.

To open the connection, give the **open** command To close the terminal connection, give the command **close**. Logging is not affected unless it is stopped using the **logstop** command. In closed mode, the serial line will be available for report sending.

NOTE Both **open** and **close** commands have to be typed exactly right before they can be executed. This means, you can not use the BACKSPACE key to correct your typing. Simply retype the command and press ENTER to give the command again.

Most of the commands can be used for both setting a value to some parameter or viewing the set value of the parameter.

Type **help** to get a list of the available commands. Each command must be entered using the correct syntax. You do not have to memorize any complex commands since at any time you can view a help text that shows the correct syntax. Just type **help** and the command name.

Table 19 Interpreting Help Texts (the Correct Syntax)

Generic Representation	Example		Note
Use the parameter name.	**warnings** [*clear*]	To see the warnings, type: **warnings** To remove warnings, type: **warnings** *clear*	Parameters shown in [ ] can be left out.
Replace parameter symbols with values.	**time** [*HH MM SS*] [*YY MM DD*]	To see current time, type: **time** To set new time, type e.g.: **time** *15 45 00* To set new time and date, type e.g.: **time** *15 45 00 01 03 20*	
	loggo <group_id>		Parameters shown in < > cannot be left out.

NOTE	Commands have to be typed in the same case as indicated in the help texts, usually in the lower case.

The command name and the following parameters are always separated by a space. Pressing ENTER (return) will execute the command so that MAWS reads the typed command.

You can use BACKSPACE to delete the last typed character.

Use CTRL+P (hold down the CTRL key and press P) to repeat the previously typed command. Use CTRL+P (Previous) and CTRL+N (Next) to scroll through the list of previously typed commands. When you find the command you would like to repeat, simply press ENTER. File commands (dir, del, copy, move, verify) can be aborted with CTRL+C.

Closing MAWS Service Connection

If your MAWS connection works via a modem, you must remember to close the line after you finish working with MAWS. To close the connection, choose **Hangup** from the **Connection** menu.

If your MAWS connection is direct, you do not need to close the service connection separately. The program closes the service connection automatically after 5 minutes.

Modifying Station Settings

In MAWS Terminal, you can modify the station settings. When you choose the **Set Stations Settings** option from the **Tools** menu, the window appears. See Figure 106 on page 114. The separate boxes in the left side of the window are for setting the common parameters to a station. The **MAWS static parameters** list shows the additional parameters, also those that have been set directly with the MAWS Terminal software.

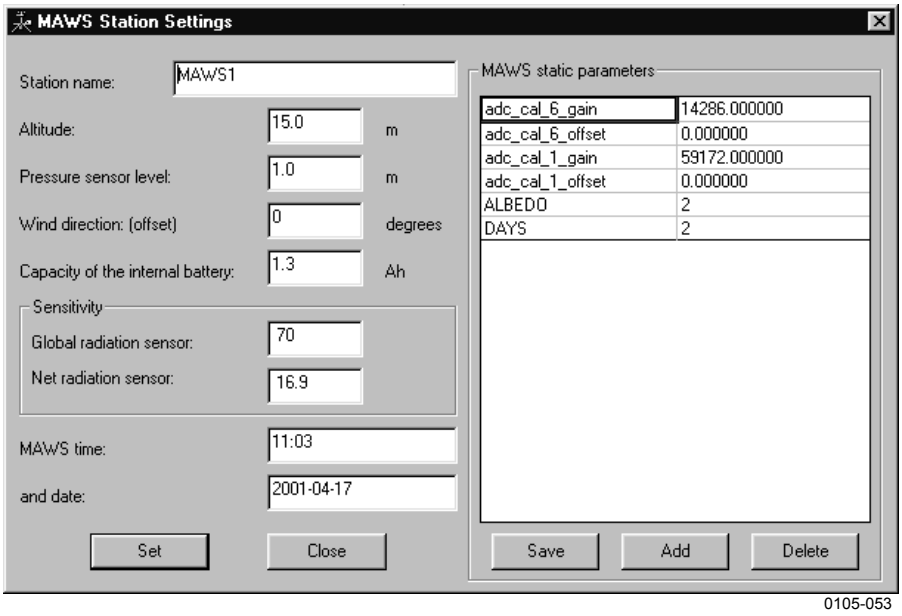


Figure 106 MAWS Station Settings Window

NOTE In the **MAWS static parameters** list, the entered values are treated as numbers by the system. When you want to enter a series of numbers as a string, write them between quotation marks (").

Table 20 below lists the items, which are changeable.

Table 20 Description of MAWS Station Settings Window

Item	Description
Station name	You can define a name for your station.
Altitude	Enter the altitude of the MAWS station from sea level.
Pressure sensor level	The height of the pressure sensor on the MAWS mast.
Wind direction: (offset)	When you are setting the wind direction sensor to the North, follow the instructions for installing MAWS. The value inserted in the **MAWS Stations Settings** window is the compass reading to the North corrected with declination. The Wind direction field shows the offset during the time when the sensor was set to the North.
Capacity of the internal battery	Enter the capacity of the MAWS internal battery QMB101.
Sensitivity values	Calibration values of the radiation sensors are written on the label of the sensors.
MAWS time and date	After you change the MAWS battery, you need to reset the system clock. Type the correct time (HH:MM) and date (YY-MM-DD) in the appropriate fields and click **Set**.
MAWS static parameters	List of static parameters (depends on your configuration).

Managing User Levels

You can use the **userlevel** command to protect the system from unauthorized use. The system provides three password protected access levels to the shell commands as well as to the visibility of system data. By default, the user levels are not in use.

You can manage user levels by the **userlevel** command when the service connection is open. The command has the following syntax:

userlevel [level <set/clear>]

where

level	=	1, 3, or 5
set	=	Sets the password for a level
clear	=	Clears the password from the level

To check the current setting, give the command alone, without parameters. When you want to change the level, give the command with parameters. When you change the level to a higher one, a password is required. When you change the level to a lower one, a password is not required.

To change the password for the level, give the command with the appropriate level and the set parameter. For this operation, the effective user level has to be the highest, that is, 5. The change of the password becomes effective immediately.

To remove the password for the level, give the command with the appropriate level and the clear parameter. For this operation, the effective user level has to be the highest, that is 5. The change of the password becomes effective immediately.

CAUTION Setting a new or clearing an existing user level is effective only after resetting MAWS. When setting a new or clearing an existing level, be sure to reset the system before closing the service connection. Otherwise, you may not be able to access the system without the cold reset.

To check the allowed commands at the specific level, give the **help** command. Table 21 on page 116 lists the accessible commands in the different user levels. Level 1 provides access to minimum set of commands and visibility of system parameters. Level 3 provides

access to all commands needed for normal administration and commissioning. Level 5 provides access to all commands. For the command reference, see Table 25 on page 129.

Table 21 Accessible Commands in Different User Levels

User Level	Commands
Userlevel 1	cd, copy, dir, errors, help, logshow, logshownext, logshowprev, logstatus, rep, warnings, and zs
Userlevel 3	EXTFS, LOGFS, altitude, battery, cd, chmod, copy, del, dir, errors, help, logdel, loggo, logshow, logshownext, logshowprev, logstatus, logstop, md, move, pslevel, rd, rep, reset, serial, sname, spclear, spset, time, timezone, verify, warnings, winddircal0, zr, and zs
Userlevel 5	All the userlevel 3 commands and the userlevel administrator rights.

MAWS Configuration File

When you start using MAWS Terminal for the first time, you need to upload a configuration file from your PC to the MAWS station.

This configuration file includes all details required by the system to function properly: which sensors the system contains, which settings they use, to which MAWS channels they are connected, and how often they calculate weather parameters. The configuration file also defines the frequency at which MAWS logs data in a file and the number of days for which data log files are kept in MAWS memory.

For archiving the configuration files save them as .dtg files to a folder in a reliable backup device. For more information, refer to the MAWS Lizard setup software User's Guide listed in Table 2 on page 15.

Selecting Configuration File

The MAWS Lizard setup software comes with some ready-made configuration files from which you can choose the one to be used. You can select the file that best suits your system. The main difference between the configurations is that with some of them, the system measures weather data more frequently, logs more variables by having more sensors, and produces more reports.

You can modify one of the configuration files with the MAWS Lizard setup software to produce exactly the configuration you want. However, this requires a thorough understanding of the system. For

more information, refer to the MAWS Lizard setup software User's Guide listed in Table 2 on page 15.

CAUTION

If you create a configuration of your own by modifying the ready-made files, store the new file under a different name. This way, you can go back to the original configuration in case the new one is not working.

Also notice that the settings you define in the configuration file must match the settings you make in the **Preferences** window and the **MAWS Stations Settings** window.

Uploading Configuration File

You need to upload the MAWS configuration file in two occasions:

- When you start using MAWS for the first time.
- When your system has been updated (for example, new sensors have been added).

When you have opened the MAWS service connection, you can start uploading the configuration file. On the **Tools** menu, select **Upload Configuration**.

The following window appears. Select the appropriate configuration file and click **Open**.

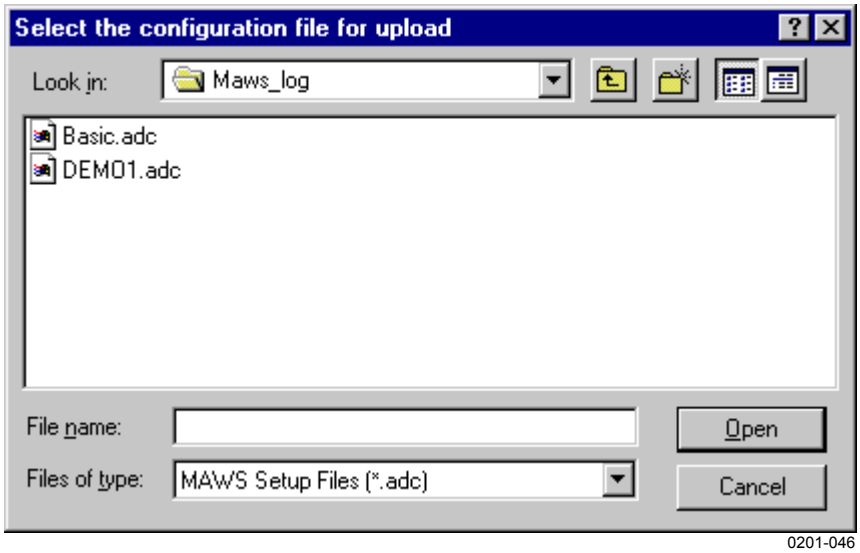


Figure 107 Selecting an Upload Configuration File

When the file has been transferred, MAWS starts logging data according to the settings in the configuration file.

After a system update (for instance, adding new sensors to your MAWS), the configuration file needs to be updated to match the changes. Normally, you need to modify the configuration file yourself with the MAWS Lizard setup software.

CAUTION	When you upload a new configuration, the system erases all data log files from MAWS. Make sure you download the files you want to save before uploading the new configuration. For more information on downloading data log files, see section Selecting Files for Downloading on page 122.

Data Logging

Logging means storing of the measured and calculated data in the MAWS internal memory, a 2 MB Flash chip. Logged data can later be retrieved via serial line.

Logged data is stored in daily files, for example, L2010326.dat that is a binary file. Naming convention is explained below:

- All log files begin with the name of the log group (max. two characters) which is followed by the date.

- Log group name usually consists of a letter followed by a number.

Everything that MAWS can measure and calculate, it can also log in its Flash memory. Approximate log memory capacity can be calculated with the following equation:

$$c = \frac{f}{m}$$

where

c = log memory capacity
f = 1 769 472 (capacity of an empty Flash memory)
m = 690 + e × (7 × p + 14) + (5 × p + 4) = memory consumed in 24 hours
e = number of logging events in one day (24 h)
p = number of logging parameters.

Example:

MAWS logs 10 parameters per minute.

e = 60 × 24 = 1440

m = 690 + 1440 × (7 × 10 + 14) + (5 × 10 + 4) = 121 704

c = 1 769 472 / 121 704 ≈ 14.5 days ≈ 2 weeks

The approximate maximum logging period for a setup where 10 measured values are logged is shown in Table 22 below.

Table 22 Log Memory Capacity

Logging Interval	Maximum Logging Period
1 second	5 hours
10 seconds	over 2 days
1 minute	2 weeks
10 minutes	over 4 months
1 hour	Almost 2 years

Log files are automatically deleted after a given period so that there is always a certain amount of logged data saved in the Flash memory. The period is adjustable in a setup and can vary from 0 (= at midnight, the previous day's file will be deleted to free up memory) to never delete (=log memory will be filled up completely. To ensure some data backup, a value of for example 4 days may be feasible. If the delete interval is set negative with the MAWS Lizard setup software, the old log files will not be deleted automatically.

Log Data Format

A log entry is generated at the time described in the setup file. When entries are retrieved with the **logshow** command, the produced output includes two parts: the header and the log entry information.

An example of a log query shows 4 entries of logged items 2, 3 and 4 starting at 10 o'clock on December 28, 1998:

```
/Log > logshow L1 d98122810 4 2 3 4
```

	Stat17:DP1_AVG	Stat18:RH1_AVG	Stat19:TA1_AVG
1998-12-28 10:00:01	V----- 1.5986	V----- 25.276	V----- 22.381
1998-12-28 10:01:01	V----- 1.5657	V----- 25.216	V----- 22.386
1998-12-28 10:02:01	V----- 1.5584	V----- 25.195	V----- 22.398
1998-12-28 10:03:01	V----- 1.5401	V----- 25.166	V----- 22.398

The header information shows the log parameter number (17, 18 and 19) and the variable name (average dew point, - relative humidity and - temperature).

The log entry information includes the time tag (date and time) of the entry, the status, and the value of the logged measurement/calculation.

Table 23 Log Entry Status

Status Indicator	Status	Description
-I-----	Invalid	Value may be outside the set scale; i.e., set climatological limits or step change validation.
-I--N-	Invalid; not available	No measurements done yet.
V-----	Valid (normal)	Measurement / calculated value available normally.

Controlling Logging

Logging is automatically on if it has been defined in the setup and if it has not been stopped. The logging needs to be stopped when:

- Today's log file is retrieved.
- A sensor is replaced (if some invalid log items can be tolerated, stopping is not necessary).

To see logging status, type **logstatus** <*group_id*>. To stop or start logging type **logstop**/**loggo** <*group_id*>.

Examples:

```
/ > logstop L1              <-------   L1 is the log group id

/ > logstatus L1
Logging OFF. Variables:
Stat15:PA1_AVG              <-------   Item number 1
Stat17:DP1_AVG              <-------   Item number 2
Stat18:RH1_AVG                         ...
Stat19:TA1_AVG                         ...
WMS302_1:WS1                           ...
Wind1:W1sAve1m                         ...
WMS302_1:WD1                           ...
Wind2:W2dAve10m             <-------   Item number 8

/ > loggo L1

/ > logstatus L1
Logging ON. Variables...
```

Freeing Up Logging Space

A log file can be deleted with the command **logdel** <log_group_id> <lastdate (dYYMMDD)>.

Example:

```
/ > logdel L2 d980910
```

To erase all data in the log system type **LOGFS ERASE**. This command erases the whole Flash memory and resets MAWS. The command **LOGFS ERASE** is necessary to free space for new log data.

Erasing the log memory with **LOGFS ERASE** command is strongly recommended when changing a setup. First, load a new configuration and make sure it is operating correctly. Check that you have retrieved all the necessary information from the log memory, then erase the log memory.

Working with Data Log Files

The best way to view the logged data is to use MAWS Terminal. To do this, you need to open the service connection, download the files from MAWS to your PC and convert them to CSV (Comma Separated Value) format. After conversion, you can view the files directly in MAWS Terminal or, for instance, in Microsoft Excel.

Before you start downloading files, you need to open the service connection by choosing the **Dial** option from the **Connection** menu. For more information on opening the connection, see section Opening MAWS Service Connection on page 110.

Selecting Files for Downloading

When you have opened the service connection to the MAWS you are working with, you need to select the data log files you want to download. Choose the **Download log files** option from the **Tools** menu. The **Select Log Files for Download** window appears.

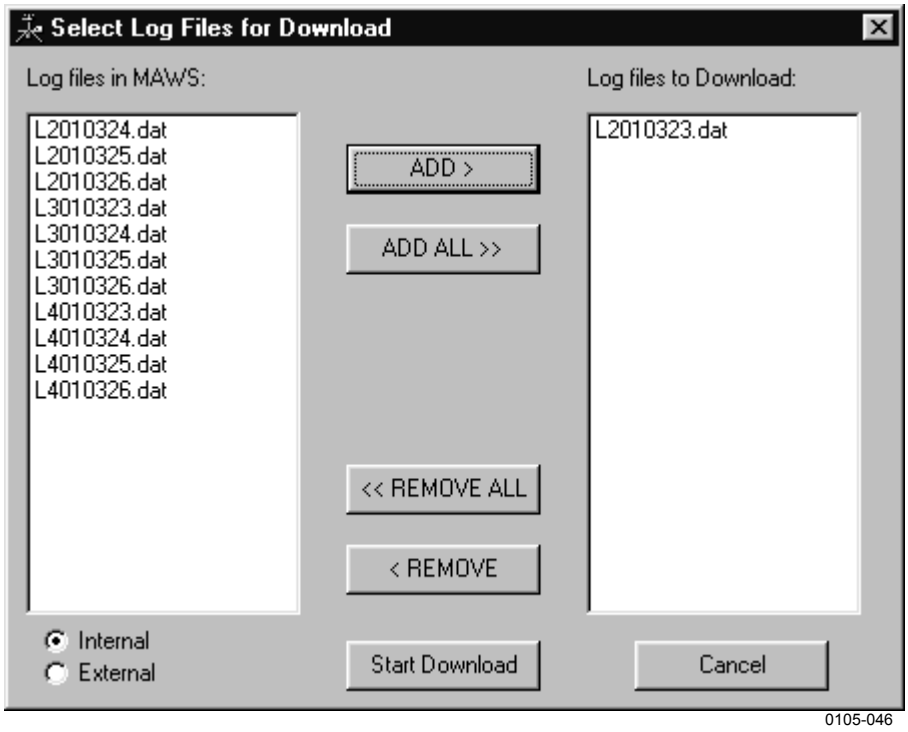


Figure 108 Select Log Files for Download Window

In the **Log files in MAWS** list, you see all data log files currently available in MAWS. The files are arranged by log group. Each log group includes specific weather parameters as defined in the configuration file.

Select the files you want to download and click **Add**. The files available for download, appear in the **Log files to Download** list. If you use an external memory card, select the **External** option. You can select all files by clicking **Add All**.

If you decide not to download a file after all, you can remove it from the **Log files to Download** list by selecting it and clicking **Remove**. To remove all files, click **Remove All**.

NOTE	The program closes the service connection automatically after 5 minutes. If you fail to start the download within 5 minutes of selecting the **Download log files**, you need to reopen the MAWS Terminal program and start the download again.

Downloading Files

When you have selected the files you want to download, click **Start Download**. The **Set Download Preferences** window appears (unless you have defined otherwise in the **Preferences window - Show Dialogs** Tab).

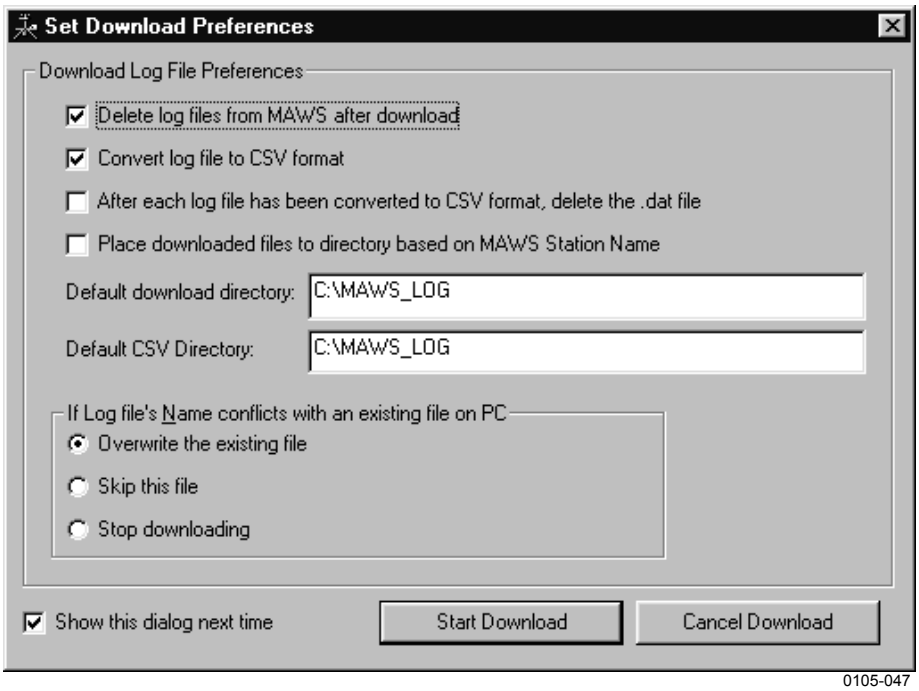


Figure 109 Set Download Preferences Window

The above window shows you the settings you have defined for the download. If you want to change any of them, you can do it in this window. Then click **Start Download**. The program downloads the data log files to your PC and converts them to CSV format automatically.

If you have selected that the data log files be deleted from the MAWS memory after download, the program asks you to confirm this.

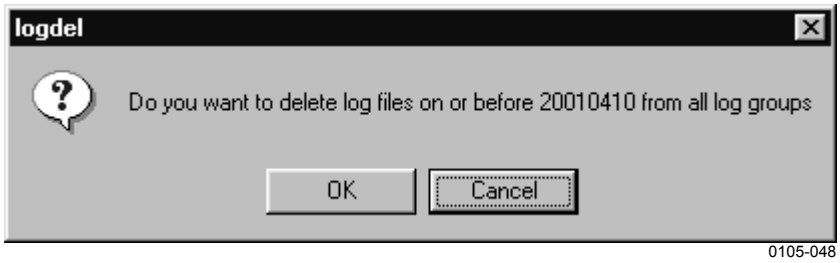


Figure 110 Confirming File Deletion after Download

CAUTION	If you select OK, all files up to the mentioned date will be deleted, regardless of whether they have been downloaded or not.

Browsing Downloaded Files

You can browse the downloaded data log files directly in MAWS Terminal.

Choose the **Offline Log Query** option from the **Tools** menu. The window shown in Figure 111 on page 125 appears.

The default directory for data log files, is the one you have specified in the **Preferences** window under the **Directories** tab. If the files you want to browse are located in some other directory, click **Change Directory**.

From the **Select Log Group** combo box, select the log group containing the file you want to work with. The files in that log group appear in the **Select Log Files** list box. Select the files you want. If you want to limit the number of data items on your screen, click **Select Data Items**.

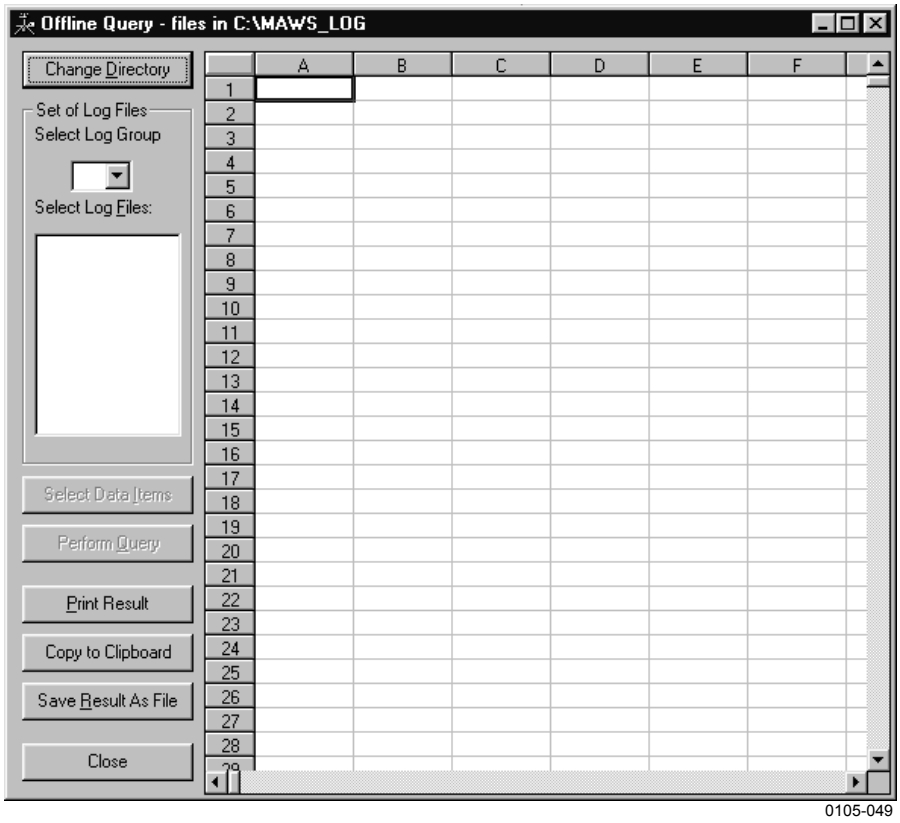


Figure 111 Offline Query Window for Browsing Data Log Files

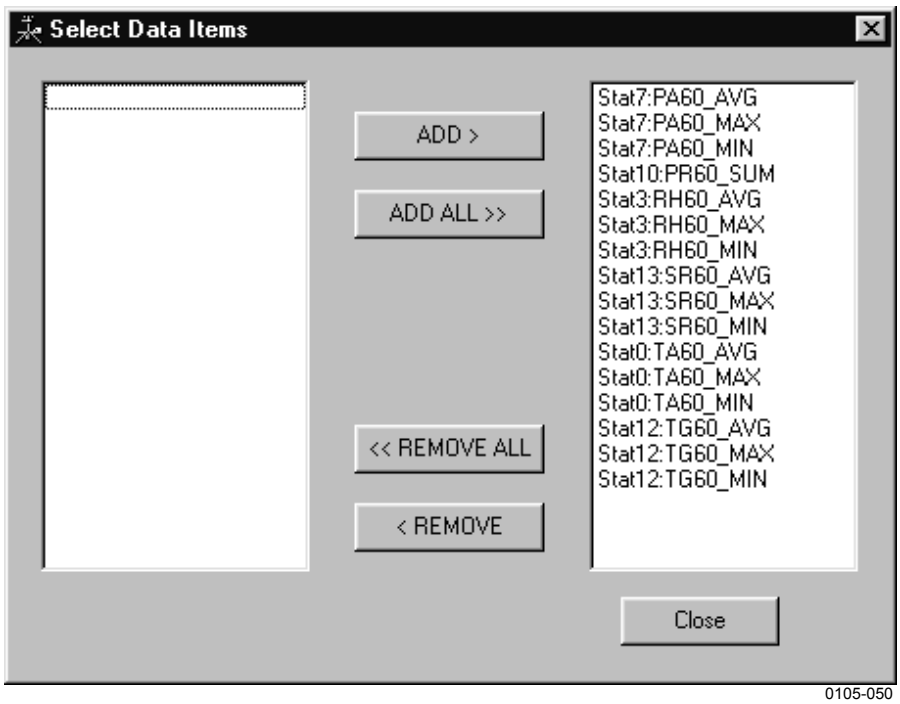


Figure 112 Select Data Items Window

In the **Select Data Items** window, you can select the data items you want to browse. All data items are selected by default. You can remove any data item, or remove them all. Once the data items you want are gathered in the right frame, click **Close**.

Click **Perform Query**. The data items you selected appear on your screen in table format.

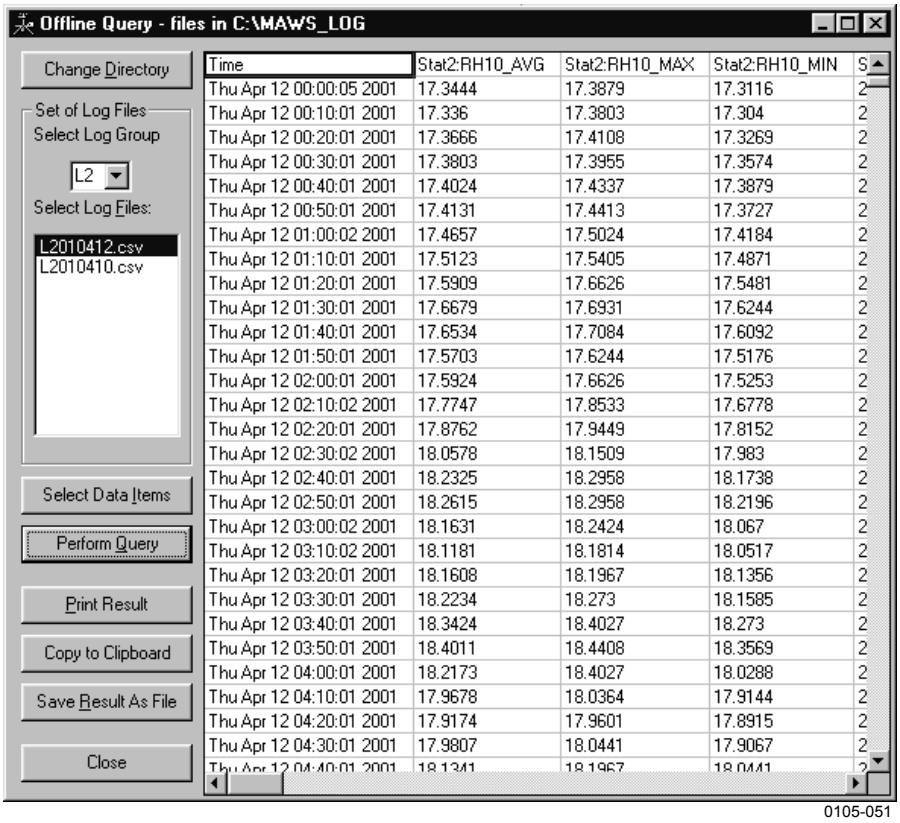


Figure 113 Offline Query Window with Data Items

If you want to view the table in Microsoft Excel, you must first save it in a tab-separated format. Click **Save Result as File**. In the window that appears, you can enter the filename and save the file in the directory of your choice. The default directory is the Default download directory you have specified in the **Preferences** window under the **Directories** tab.

When you have finished browsing the data log file, click **Close**.

Converting Data Log Files to CSV Format

If you have selected the Convert file to CSV format option in the **Preferences** window, **Download** tab, the program converts the data log files into CSV format as you download them. However, if you prefer to download the files without converting them, you can do this by choosing the **Convert files to CSV** option from the **Tools** menu.

When you select the **Convert files to CSV** option, the following window appears.

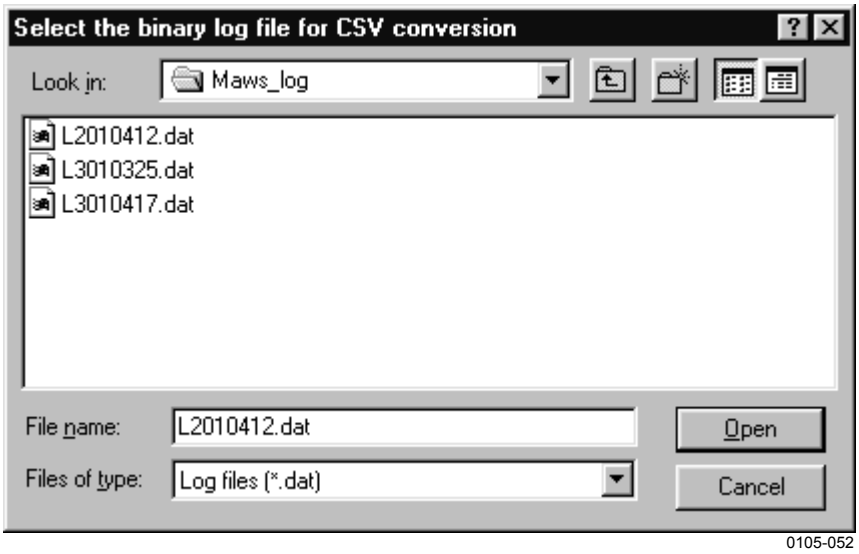


Figure 114 Selecting a Binary Log File for CSV Conversion

Select the file you want to convert to CSV format and click **Open**. The program starts the conversion. When the conversion is complete, the CSV file is saved in the directory you have specified in the **Preferences** window under the **Directories** tab.

Using External Memory Card

The external memory card is used to store log files that have been copied or moved from the internal log directory. The data can be retrieved from the external memory card via terminal connection or by switching the memory card with an empty one.

Note that the memory card must be formatted with a command **EXTFS** *ERASE* before use.

The external memory card can be removed from MAWS for data retrieval without interruptions to MAWS operations. MAWS copies

data from the internal log directory to the memory card daily at midnight, the default time is 00:00:30. The data is being written, when the LED on the logger cover to the left of the external memory card is constantly on.

CAUTION	The memory card must not be removed from MAWS while data is being written or the data may be lost.

When a new memory card is inserted into MAWS, the software checks that the card is ready for use. The status of the memory card is indicated by a LED. Table 24 below describes the different blinking sequences and the card conditions they indicate.

Table 24 LED Blinking Sequences and Card Status Options

Blinking Sequence	Card Status
Long-long	The card is OK.
Constantly on	Data is being written.
Short-short-short for 5 seconds	The card is unformatted or corrupted.

Resetting MAWS

To reset MAWS, give the command **reset** (recommended) or press the reset button (see Figure 4 on page 24).

A short reset (pressing the reset button quickly) performs the same reset as giving the command and starts the program again. A long reset (pressing the reset button and keeping it down for a few seconds) restarts the program with a so-called "blank" setup. A blank setup does not run a configuration file.

The blank setup may be useful if configuration is somehow defective and does not allow the user to open a terminal connection. When the blank setup is run, MAWS communication parameters are restored to their defaults: COM0, 9600, N, 8, N, 1.

Command Reference for Terminal Connection

Table 25 Command Set

Command	Description
altitude	altitude [meters]. To see the current station altitude, type **altitude**. To change the altitude, type **altitude** and the new station altitude in meters from sea level.
battery	battery [capacity] sets the capacity of the internal battery, needed for MAWS internal control. Accepted capacity values are 1.2 ... 24 Ah. To see the battery status, type **battery**.
cd	cd [directory path] changes the current directory. **cd /** gets you back to the root directory. NOTE! cd .. Cannot be used.
chmod	chmod <filename> <r/w/x> changes the file access attributes: read (r), write (w) or execute (x). The setup file "Basic/Advanced/Lowpower" needs to have attributes rwx.
close	Closes terminal connection.
copy	copy <source file> <destination file> copies a file to another location.
del	del <filename> deletes a specified file. Only files that have (w)rite access attribute can be deleted (see command chmod).
dir	dir [file/path] displays a list of a directory's files and subdirectories, used and free disk space. The file information includes name, access_attributes, time, date and size.
errors	errors [clear]. To see active errors, type **errors**. To clear active errors, type **errors clear**. Errors indicate that there is something wrong in the software.
EXTFS	EXTFS <INFO|ERASE>. To format Compact Flash card, type **EXTFS ERASE**. To show card info, type **EXTFS INFO**. NOTE! The command must be written in upper case.
help	help [command] displays a command syntax. To list all the available commands, type **help**.
LASTVAL	LASTVAL [Measurement] [raw | Signal name] shows the measured value before any validation and the status produced during validation. The validated value is shown when you give the signal name.
logdel	logdel <log_group_id> <lastdate (dYYMMDD)> deletes a log file/files dated earlier than the last given date.
LOGFS	LOGFS <ERASE> erases all data in the log system and resets MAWS. NOTE! The command must be written in upper case.
loggo	loggo <log_group_id> starts logging of the defined log group.
logshow	logshow <log_group_id> [start (YYMMDDHH)] [count] [item numbers] logshow L1 shows one line of current day logshow L1 40 shows 40 lines logshow L1 40 3 shows 40 lines of item 3 logshow L1 001120 10 shows 10 lines starting from 20.11.2000
logshownext	logshownext <log_group_id> [count]. After the **logshow** command, can be used to show the immediately following (later) log entries.
logshowprev	logshowprev <log_group_id> [count]. After the **logshow** command, can be used to show the immediately preceding (earlier) log entries.
logstatus	logstatus [log_group_id] shows logging state and variables of the defined log group. The command without parameters shows statuses of all log groups.
logstop	logstop <log_group_id> stops logging of the defined log group.
md	md <path> creates directory. E.g. md /Ext/logdata
move	move <source file> <destination file> copies a file to another location and

	removes the source file.
open	Opens the terminal connection.
pslevel	pslevel [meters]. To see the current pressure sensor level, type **pslevel**. To change the pressure sensor level, type **pslevel** and the new pressure sensor level in meters from the station altitude.
rd	rd <path> removes directory
rep	rep <report_name> shows contents of a report report_name. E.g. "rep MyRep0".
reset	reset [delay (seconds)] resets MAWS (warm boot). If the delay time is not typed, MAWS resets immediately.
serial	serial <port_number> [speed] [parity] [bits] [stop]. To see the settings of the port number 0, type **serial 0**. To change the settings, type **serial 0** and the new parameters. E.g. "serial 0 9600 N 8 1". Available ranges/options: Speed 300-19200, Parity N/O/E, Bits 7/8, Stop 0/1.
SLEEP	Sets MAWS in low power-state. Use the **SLEEP** command to reduce power consumption when storing the station for a few days (maximum period 1 month). Tip the spoon of the rain gauge to wake up MAWS. MAWS can also be woken up by pressing the reset button. NOTE! The **SLEEP** command must be written in upper case.
sname	sname [station_name]. To see the current station name, type **sname**. To change the name, type **sname** and the new name. If the station name begins with a digit or contains a space, the name must be in quotes e.g. sname "Vaisala MAWS".
spclear	spclear <parameter/ALL> clears a static parameter/all parameters. NOTE! This command clears QMS101 and QMN101 sensitivity settings and is not usually needed.
spset	spset [parameter] [value] sets a value to a static parameter. To see a list of static parameters, type **spset**. NOTE! This command is not usually needed.
SYSINFO	SYSINFO gives information on the system. NOTE! The command must be written in upper case.
time	time [HH MM SS YY MM DD]. To see the current time, type **time**. To change the current time, type **time** and the new time. E.g. "time 14 10 00". To change the current date, type **time** and the new time and date e.g. "time 14 10 00 98 12 31".
timezone	timezone [hours] sets the time difference from UTC. To see the time zone, type **timezone**. To set the time zone, type e.g. "timezone 2".
userlevel	**userlevel** [level <set/clear>]command is used to protect system from unauthorized use. It provides three password protected access levels to shell commands as well as to the visibility of system data. By default, the user levels are not in use.
verify	verify <source file> <destination file> verifies file(s)
warnings	warnings [clear]. To see active warnings, type **warnings**. To clear active warnings, type **warnings clear**. Warnings indicate that there are some problems in the software. See the Troubleshooting chapter on page 153 for more information.
winddircal0	winddircal0 [direction]. Set the direction in degrees to align the wind vane. Type for example "winddircal0 360" (north).
zr	Zmodem receive command is needed when transferring the setup file to MAWS.
zs	zs <file_name>. Sends a file from MAWS using Zmodem protocol.

NOTE **Winddircal0**, **ADCAL6**, and **ADCAL1** commands are available only when MAWS has a setup file loaded and running.

NOTE The following commands allow the use of wild cards: chmod, dir, del, copy, move, verify, zs.

Example:

```
dir L1*.*
copy /log/L2*.* /Ext/log_L2
chmod *.* rw
```

NOTE File commands (**dir**, **del**, **copy**, **move**, and **verify**) can be aborted by typing CTRL+C.

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CHAPTER 5

MAINTENANCE

This chapter provides information that is needed in the basic maintenance of MAWS.

The purpose of periodic maintenance is to keep sensors operational and safe, measurements reliable, and to define if any calibration actions are needed.

Under normal conditions, the MAWS weather station needs only a minimum amount of maintenance. The need for maintenance depends on the sensors that are connected to your MAWS.

CAUTION	Do not open the MAWS logger housing under poor conditions (for example, rain or dust in the air). In general, it is not advisable to repair sensors in the field.

Routine Maintenance and Calibration

Regular maintenance of the MAWS system, its sensors, and accessories is essential to ensure the correctness of the data and to extend the lifetime of the system. Periodic routine maintenance tasks include checking, cleaning, and servicing all the system elements and repairing or replacing the damaged or worn-out components.

The maintenance task should be accomplished only by a technician properly trained for these tasks. The technician must be familiar with the system and know how each component of the system performs. In addition, adequate tools and test equipment have to be at hand to complete the maintenance tasks successfully.

When using high quality sensors and system, most of the routine maintenance tasks can be performed at the installation site. Some instruments and advanced calibrations and refurbishments, require the sensor be returned to the laboratory for proper calibration. When system components need to be brought in from the field, the best procedure is to maintain an inventory of spare components. The user can then exchange a component with a calibrated component or sensor during a single visit. This is the case especially with sensors that must be returned to the manufacturer for calibration.

Before the maintenance actions, certain preparations must be made in order to make the work successful:

- Obtain information on how the site has been functioning before the scheduled maintenance.
- Obtain information on what maintenance tasks were completed during the previous maintenance procedure.
- Make sure that you have all the necessary tools available. The required set of tools depends on the system configuration, however the minimum is listed below:
    - A laptop PC with multiple fully charged batteries.
    - The latest operational versions of the MAWS operating software version, MAWS Lizard Setup Software, and MAWS Terminal software.
    - The configuration file which is used at that particular station to be maintained.
    - All the necessary system documentation.
    - MAWS Terminal cable (QMZ101).
    - Hand held tools; screw drivers, wrenches, pliers, wire cutters, and insulation strippers.
    - Digital multimeter.
    - Clean cloth, cleaning solution, and cleaning brush.
    - Lubricant.
    - Anti-seize compound.
    - Safety harness, if tower climbing is required.
    - All the necessary parts to be changed regularly.
- Make a list of all the sensors requiring replacement with refurbished and calibrated units.

Overall Checking

- Check signal and main cables, connectors, and connections.
- Check gaskets of the enclosures.
- Check all grounding cables, lugs, etc.
- Check mechanical assemblies, bolts, nuts, etc.
- Check for corrosion. Repair if needed.

NOTE	Use the correct tools of good quality.

Sensors and Accessories

Solar Panel

Inspect the module twice a year for overall integrity. Make sure that connections to the battery are tight and free of corrosion.

Dirt accumulation on the module's front surface can reduce the light energy collected by the module. If the module surface is dirty, gently clean it with a soft cloth or sponge using water and mild detergent.

WARNING	Wear rubber gloves to protect yourself against possible electric shock.

CAUTION	Do not use a scrub brush; it can damage the module front surface.

Wind Sensor

It is recommended to check the ball bearings of the anemometer and the vane every year. If the cup wheel or the vane is not rotating smoothly or creates detectable noise, the bearings must be replaced (refer to Figure 115 on page 137).

Anemometer bearings:

1. Loosen the hubnut (14) with fingers or a 10-mm tool and remove the cup wheel (13).
2. Remove the ball bearing assembly (12) by unscrewing it counterclockwise (with a 10-mm tool).
3. Insert a new bearing assembly (12) and tighten gently.
4. Fasten the cup wheel to the sensor and tighten gently.

Vane bearings:

1. Proceed as described in steps 1 and 2 above.
2. Open the lock screw (11) of the assembly (10) and remove it.
3. Remove the Seeger-ring (9) (with narrow point pliers).
4. Remove the bearing assembly (8).
5. Replace the bearings inside the housing with new ones.
6. Assemble the sensor in the reverse work order.

Due to normal wear, it may become necessary to renew the direction potentiometer or the anemometer electronics assembly.

1. Remove the sensor housing parts.
2. Open the body (1+6) by unscrewing it clockwise.
3. To replace the potentiometer, proceed as follows:
   a. Pull the potentiometer PCB (2b) out from the sleeve (4).
   b. Unsolder the potentiometer wires from the PCB.
   c. Solder new potentiometer wires to the PCB.
   d. Push the PCB (2b) into the plastic sleeve (4) by pressing the sleeve sides. Note the guide holes.
4. To replace the reed-switch PCB, proceed as follows:
   a. Pull out the retainer flange (3) and the reed-switch PCB (2b).
   b. Unsolder the old wires and solder new ones for the PCB.
   c. Push the PCB into the tube of the casing (1).
   d. Fit the flat wire to the groove at the casing wall and insert the retainer flange. Make sure that the flat wire is pressed tightly against the casing wall.

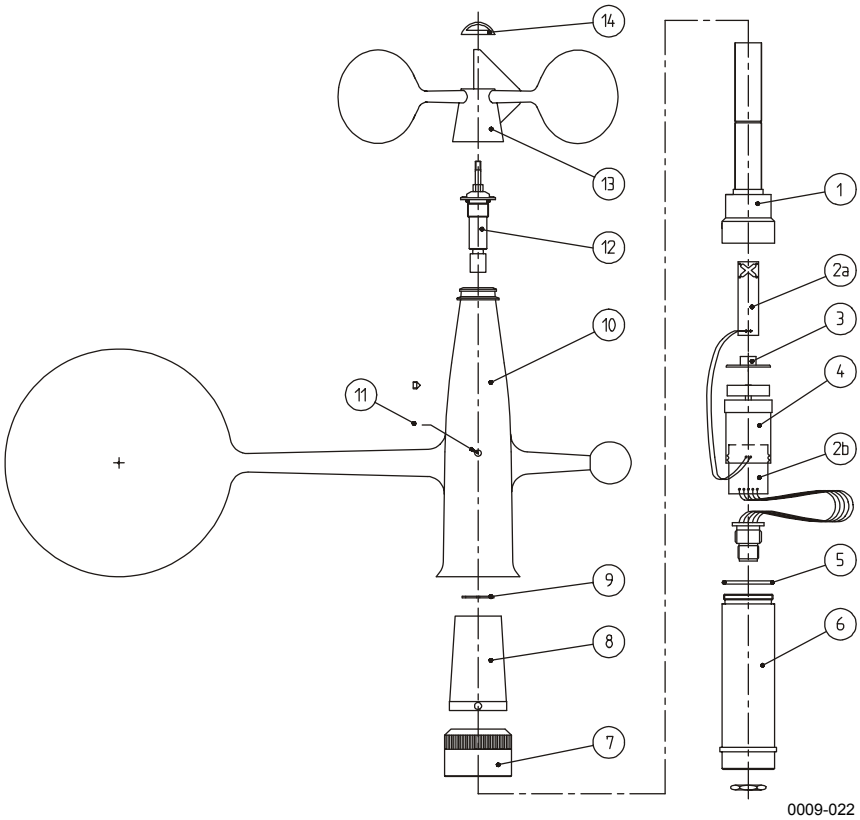

Figure 115 QMW101/QMV110 Sensor Assembly

5. Insert the potentiometer assembly into the upper part tubing.
6. Screw the body parts (1) and (6) together. Tighten carefully.
7. Ensure that the mast adapter sleeve (7) is on the base part (6).
8. Place the bearing housing (8) to the casing and secure it with a Seeger-ring (9).
9. Place the vane assembly (10) onto the body. The lock screw hollow at the casing must be seen through the lock screw hole of the vane body.
10. Fasten the assembly with a lock screw (11) and tighten gently.
11. Screw the bearing housing (12) into the casing (1) and tighten gently.
12. Fasten the cup wheel to the sensor shaft.

Air Temperature and Relative Humidity Sensor

Calibration and maintenance of the air temperature and relative humidity probe should be performed at regular intervals, depending on the conditions of use and desired accuracy. The validity of the readings should be checked annually.

The QMH101 probes are easy to maintain and calibrate. The probe consists of a probe head and a handle with cable. All calibration electronics are in the probe head, which can be disconnected from the handle without disconnecting the wires, as shown in Figure 116 below. If you wish to continue the measurement immediately, you can insert a calibrated probe head in place of the disconnected one; this way, the measurement is interrupted for less than a minute.

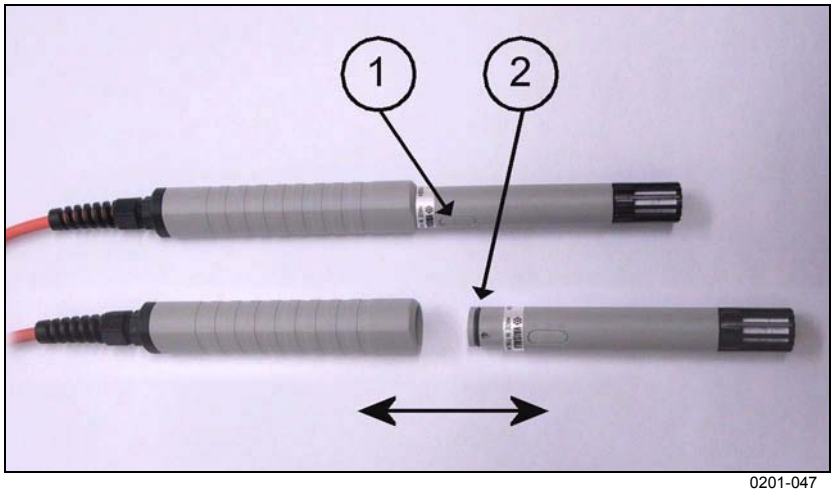

Figure 116 QMH101 Probe Maintenance

The following numbers refer to Figure 116 above.

1 = Adjustment trimmers: W=wet, D=dry, (T=temperature; for factory use only)
2 = O-ring for sealing the probe weather tight

Humidity Calibration

For a high-accuracy two-point calibration, use a Vaisala HMK15 or HMK13B calibrator and saturated salt solutions. See respective manuals for details.

Leave the calibrator and the probe head in the same space for at least four hours so that their temperatures have time to equalize. Unscrew the plastic grid of the probe.

The calibration is done first for the dry end (<50 %RH) and then for the wet end (>50 %RH) by adjusting the trimmer potentiometers marked with **D** and **W**. The potentiometers are located under a protective plug, see Figure 116 on page 138. Use a ceramic screwdriver with 2.5 mm blade for adjusting the potentiometers. Note: if zero point is calibrated in Nitrogen (N_2), the minimum output signal of 0.008 V corresponds to a relative humidity of 0.8 %RH.

Table 26 Greenspan's Calibration

Temperature [°C]	15	20	25	30	35
LiCl [%RH]	*)	11.3	11.3	11.3	11.3
NaCl [%RH]	75.6	75.5	75.3	75.1	74.9
K_2SO_4 [%RH]	97.9	97.6	97.3	97.0	96.7

*) Do not use or store the LiCl solution in temperatures below +18 °C as its humidity equilibrium may change permanently.

As the D (dry) and W (wet) adjustments may affect each other, re-check the humidity reading at the low end. If necessary, repeat the adjustments in both the low and the high humidity points, until the reading is correct.

Changing the HUMICAP®180 Humidity Sensor

Unscrew the filter. Remove the damaged sensor and mount a new HUMICAP®180 humidity sensor in its place. Handle the sensor with care. Calibrate the probe using a two-point calibration procedure. Note that if the probe is not calibrated, the accuracy is still better than ±7 %RH.

Pressure Sensor

Under normal operating conditions, PMT16A Pressure Sensor needs only a minimum amount of maintenance.

- Keep the pressure port clean.
- Annually, compare pressure values against a calibrated portable standard.

Calibration

The MAWS software provides means for one-point field calibration of PMT16A. Required equipment:

- Laptop PC with a terminal software
- A standard barometer (for example Vaisala PTB220TS)
- Terminal cable QMZ101 (delivered with MAWS).

Table 27 Calibration Procedure

Step	Action	Command/note
1.	Establish terminal connection to MAWS by connecting the terminal cable between COM0 port of MAWS and a COM port on your PC.	For more information, refer to section Establishing Terminal Connection on page 104.
2.	Place both pressure sensors at the same level.	NOTE! Make sure that the wind does not interfere with the reading of the reference barometer.
3.	Read the reference barometer reading.	
4.	Give this reference reading, for example 1003.7 hPa, to MAWS.	Type: PMT16CAL 1003.7
5.	Check the readings given by MAWS.	Value = (reference reading) Measured value = measured by MAWS Offset = measured value - reference reading
6.	Repeat the calibration if necessary.	
7.	Close the terminal connection.	Give command **close**

Precipitation Sensors

QMR101

To ensure reliable and accurate measurements, we recommend that the following checks be carried out at each visit to the rain gauge.

NOTE If the gauge is still connected to the data logger and logger is operating, care must be taken to avoid tipping the spoon/bucket when carrying out the following operations.

1. Inspect the funnel for any damage or blockage. At certain times of year, leaves may have accumulated into the funnel. Dirt and dust can also block the grille preventing or reducing the flow rate to a slow drip to the buckets beneath. Remove all obstacles from the funnel.

2. Check that the gauge is still level. It is surprisingly easy for an apparently immovable gauge to become tilted as a result of small ground movements, vandalism, or just an inquisitive finger.
3. Clean the spoon from dust and dirt once or twice a year to ensure a precise measuring.

QMR102

To ensure reliable and accurate measurements, Vaisala recommends that the following checks be carried out at each visit to the rain gauge.

NOTE	If the gauge is connected to the data logger and the logger is operating, avoid tipping the cup assembly.

1. Inspect the funnel and filter for any damage or blockage. At certain times of the year leaves may have accumulated in the funnel, dirt and dust can also block the filter preventing or reducing the flow rate to a slow drip into the buckets beneath. The leaves can easily be removed from the funnel and the filter can be cleaned by removing the end cap from the filter tube. Remove the filter material carefully, clean and replace the filter and cap.
2. Check that the gauge is still level. It is surprisingly easy for an apparently immovable gauge to become tilted as a result of small ground movements, vandalism or just an inquisitive finger.
3. Remove and clean any dirt from the bucket.
4. There will be times when the rain gauge will not log or will be disconnected from the logger. In such cases, it is a good idea to check the balance arm of the bucket for stiffness. The easiest way to do this in the field is to try to balance the bucket in its center position. It should be very difficult, if not impossible, to achieve this. If the bucket balances easily then examine the bucket closely for any dirt or wear on the pivot pin and bucket tubes.

Calibration

The sensitivity of the rain gauge is accurately calibrated by the manufacturer to a nominal 0.2 mm/tip. Each rain gauge is supplied with its own calibration figure. A purpose built calibration rig that

supplies an adjustable constant head of water and allows for accurate calibration of the rain gauge.

Manufacturer also provides a re-calibration and overhaul service to customers; however, this section describes a good alternative for re-calibrating the rain gauge if the user wishes to do so.

Static Calibration

1. Before re-calibrating the rain gauge take this opportunity to carry out any other maintenance that may be required.
2. Install the gauge over a sink as illustrated in Figure 117 below, ensuring that it is correctly leveled (the RGB1 base plate can be used for this).
3. Using a burette or pipette, slowly drip in 10.13 cm^3 of water for 0.2 mm/tip. The bucket should tip on the last drip of water. Adjust the relevant thumb screw, (located under each bucket) until the above condition is met. Repeat the procedure for other side of the bucket.

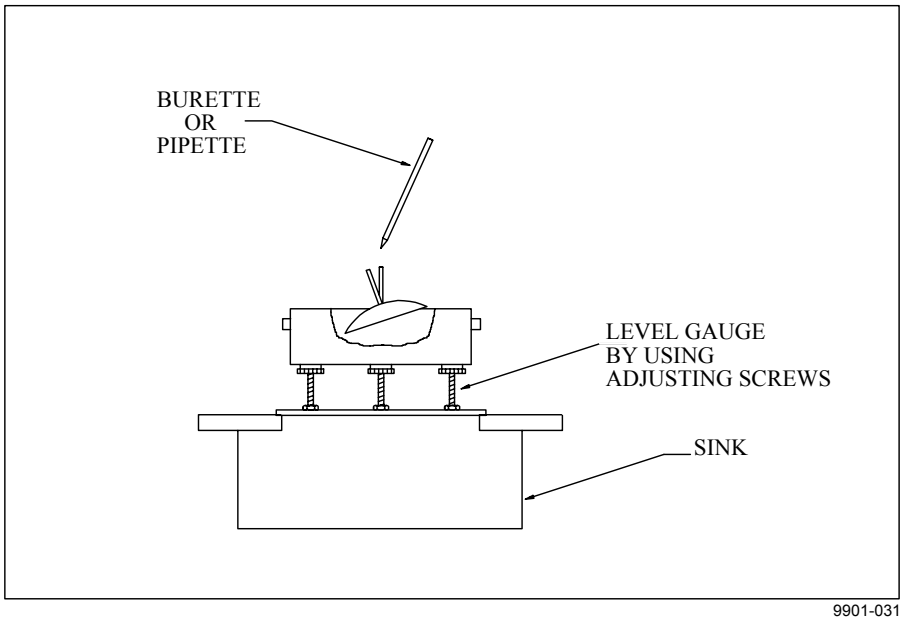

Figure 117 Static Calibration

It is not possible to set the screws very precisely using this method, but it should be done with as much care as possible. It is obviously very important that both buckets tip in response to the same amount of water. Many manufacturers and users of tipping bucket rain gauges try to adjust the buckets settings until exactly the correct calibration is achieved. However, a dynamic test is required to check this calibration precisely after each readjustment and the process becomes very time-

consuming. In any case, it is virtually impossible to get the adjustments absolutely correct, and it is generally preferable to adjust the settings as closely as is reasonably practical, and then derive a calibration factor for each rain gauge individually after dynamic calibration.

Dynamic Calibration

1. Configure the gauge as shown in Figure 118 below or Figure 119 on page 144 (the latter setup will give a preferable constant flow rate), ensure the gauge is leveled and connected to a data logger or counter.
2. Fill a container with 1000 cm^3 of water for 0.2 mm/tip calibration. This is usually achieved most precisely and consistently by weighing the water on a balance capable of measuring to 0.1 g (0.1 cm^3). An alternative is to use a good quality graduated measuring cylinder.
3. Allow the water to drip slowly into the gauge, taking at least 60 minutes to empty (approximately 40 seconds for each tip). At the end of this period approximately 98 tips will have occurred. The exact number is obtained from the data logger or counter. To this, add on an accurate estimation of what fraction of a tip is left in the bucket when the water stops flowing (a graduated syringe is ideal for this).

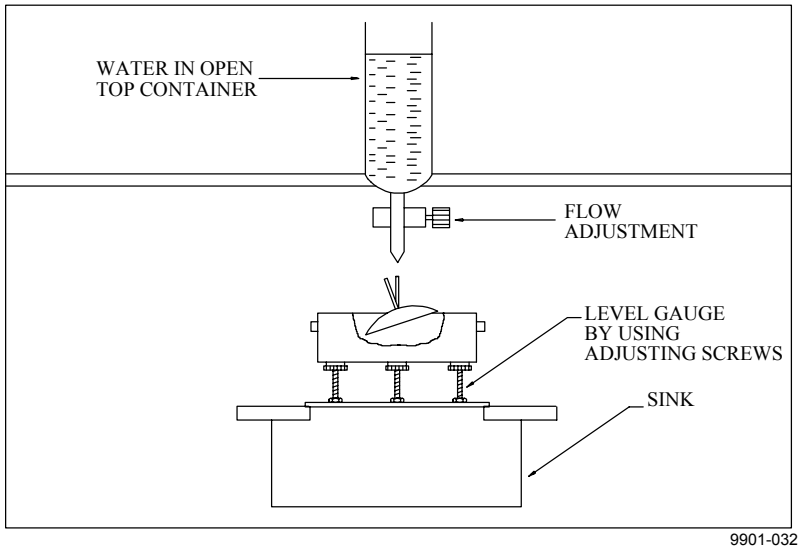

Figure 118 Dynamic Calibration

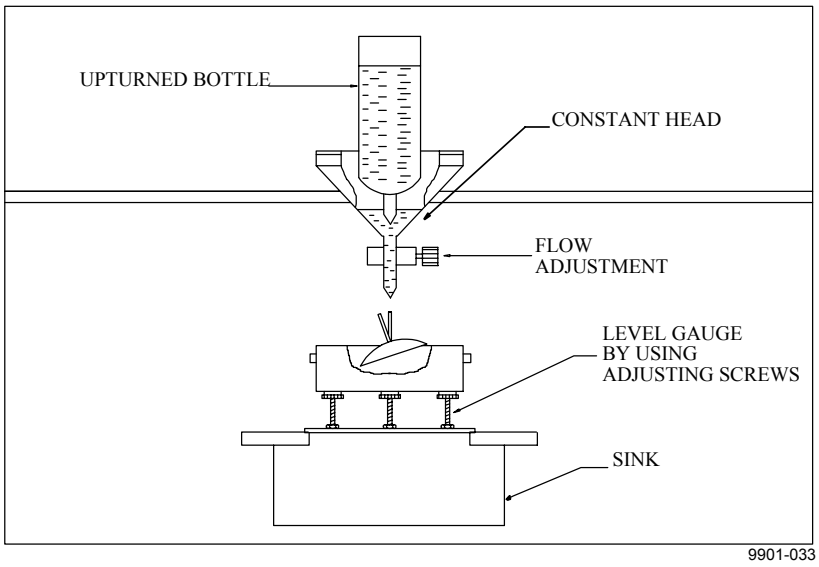

Figure 119 Dynamic Calibration (Constant Head)

Calculating the Calibration Factor

Using the figures from the dynamic calibration, the calibration factor can now be read from Table 28 on page 145, or you may wish to calculate the calibration factor using the following formula.

The nominal amount of tips for a 0.2 mm bucket is 98.7167 tips. Let N = the number of tips (together with the fractional part left in one bucket), the calibration factor (C.F.) is then calculated as follows (in the example below, we will use 99.3 tips as N).

C.F. = Gauge size × Nominal / N

C.F. = 0.2 mm × 98.7167 / 99.3 tips

C.F. = 0.1988 mm / tip

C.F. = 0.199 mm / (tip rounded off)

In other words, each tip corresponds to 0.199 mm of rainfall. Provided the C.F. falls between 0.197 mm and 0.204 mm it is acceptable for most purposes. If the C.F. lies outside these limits, repeat the static and dynamic calibration procedures.

Table 28 Calibration Factors

Number of tips	C.F.
96.7 to 96.9	0.204 mm/tip
97.0 to 97.4	0.203 mm/tip
97.5 to 97.9	0.202 mm/tip
98.0 to 98.4	0.201 mm/tip
98.5 to 98.9	0.200 mm/tip
99.0 to 99.4	0.199 mm/tip
99.5 to 99.9	0.198 mm/tip
100 to 100.4	0.197 mm/tip

Solar Radiation Sensors

QMS101

The pyranometer is an all weather instrument.

Once installed the pyranometer needs little maintenance. It is recommended that you clean the detector as part of a regular routine, using water or alcohol.

Re-calibration is suggested every two years. This can be done in two ways. The first is to compare with the measurement of a similar sensor at the same site. Preferably, daily totals of several days should be compared. Calibration factor could be corrected if results differ by more than five percent. The second way is to let a re-calibration be performed at the factory.

If necessary, the sensitivity of the pyranometer can be adjusted. This can be done by soldering a resistor between the + (white) and - (black) output wires. In this way the pyranometer is shunted. For the standard pyranometer, the internal resistance is 47 Ω, and the cable resistance is 0.12 Ω per meter. The cable is 3 meters long. The cable resistance has to be multiplied by two, for the + and - wire. Total resistance is 47.7 Ω. In order to reduce the sensitivity by a factor of 10, when the full 3 meters of cable is used, a shunt resistor of 5.3 Ω can be made out of a 1 and a 4.3 Ω resistor. The order of magnitude for the sensitivity will be 10 $\mu V/Wm^{-2}$.

The general formula for establishing the proper resistor for trimming by a factor of 10 is [47 + (0.24 × cable length)]/9. The cable length is in meters and the resistance is in ohms.

QMS102

The pyranometer is an all weather instrument. Once installed the pyranometer needs little maintenance. It is recommended that you clean the detector as part of a regular routine, using water or alcohol.

Re-calibration is suggested every two years. This can be done in two ways. The first is to compare with the measurement of a similar sensor at the same site. Daily totals of at least two days should be compared. Calibration factor should be corrected if results differ by more than six per cent. The second way is to let a re-calibration be performed at the factory.

QMN101

The net radiometer is an all weather instrument. Once installed it needs little maintenance. It is recommended that you clean the detector as part of a regular routine, using water or alcohol.

Re-calibration is suggested every two years, preferably by letting a higher standard run parallel to it for two sunny days, and by comparing the daily totals over several days. The calibration factor could be corrected if the results differ by more than five percent. The reference could be a net radiometer type CNR1, or a QMN101 that is kept safely in a cupboard.

Another way of checking sensor performance during field use is to put the sensor upside down during stable atmospheric conditions. Theoretically, the sensor output should change sign. Please mind that the sensor response time for stabilizing is about one minute. This method is no more accurate than 20% due to the fact that the sensor symmetry is no more accurate than this.

A third way is to let a re-calibration be performed at the factory.

Soil Temperature Sensors

QMT103

The probe does no need any regular maintenance. Field repairs are accomplished by replacing the complete probe.

QMT107

When the probe is extracted, clean the dirt accumulation on the probe's surface with a soft cloth or sponge using water and mild detergent. Field repairs are accomplished by replacing the complete probe.

Soil Moisture Sensor

The ML2x probe is sealed after the factory calibration. It does not require any routine maintenance and it is constructed of materials selected for robust field operation. If the measurement rods become bent in use, they can be carefully unscrewed from the body and straightened. They have a right-handed thread. Please pay special attention to the following points:

- Do not remove the cross-head sealing screws. This may damage the seal and will invalidate your guarantee. No internal maintenance or repair shall be performed by the user.
- Do not remove the probe from soil by pulling on the cable.
- Do not attempt to straighten the measurement rods while they are still attached to the probe body. This may break the rods or damage the case seal.

Water Level Sensors

QMV101/QMV102

To ensure reliable and accurate measurements, we recommend that during each visit to the QMV101 Water Level Sensor the following checks be made:

1. Check the drying detergent through the window of the junction box.
2. If the drying detergent has turned red, change the cartridge. The cartridge has reached its internal maximum absorption of humidity. Replace the cartridge and adjust the interval for the next visit.

CAUTION	The drying detergent is very important to ensure reliable performance of the water level sensor. Otherwise humidity enters the sensor casing through the ventilation pipe inside the cable and causes severe damage to the sensor.

Leaf Wetness Sensor

The QLW101 Leaf Wetness Sensor does not need any regular maintenance. Field repairs are accomplished by replacing the complete probe.

Fuel Moisture Sensor

The sensing element of QFM101 Fuel Moisture sensor is a wooden dowel that exchanges moisture with its surroundings. In the course of a year, it undergoes many cycles of soaking up moisture and drying. These processes eventually cause the structure of the wood to deteriorate. Similarly, dust and other contaminants become imbedded in the surface and they change the surface properties. When this occurs, the calibration is no longer valid.

The only way to restore the sensor accuracy is to replace the wooden dowel, which must be done at the factory.

Your experience will eventually determine how frequently the sensor needs service. At the beginning, the manufacturer recommends that you return it to the factory once a year for replacement of the dowel and calibration.

At most sites, where the sensor is used to assess fire danger, there is a season when the danger is low. That is usually a good time to replace or refurbish the sensor.

Cable Maintenance

Inspect cables for breaks, cracks in the protective coating or cable connectors, and bent, damaged, or misaligned pins. Also wipe off or remove excess dirt, dust, sand, or leaves.

Spare Parts

Available Spare Parts

Table 29 Available Spare Parts

Spare part name	For...	Order code
Cup wheel assembly	QMW101	WA45233
Anemometer bearing assembly	QMW101	WA45232
Vane assembly	QMW101	WA35234
Vane bearings assembly	QMW101	WA45247
Humidity sensor	QMH101	HUMICAP®180
Temperature sensor Pt 100 IEC 751 1/3 Class B (HMP45D)	QMH101	19159
Membrane filter (standard)	QMH101	2787HM
HMP45D probe head	QMH101	HMP45DSP

Ordering Spare Parts

Contact your local Vaisala representative for a complete list of spare parts and for ordering spare parts or optional units.

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CHAPTER 6
TROUBLESHOOTING

This section consists of some common MAWS problems, their probable causes, and remedies.

Data Validation

For most of the sensor inputs, there are data validation parameters to check the following measurement's quality parameters:

- Maximum value: the maximum climatological value for the sensor measurement.
- Minimum value: the minimum climatological value for the sensor measurement.
- Step change: the maximum step change for the sensor value between two consecutive measurements.

All of these parameters can be set by the user using the MAWS Lizard setup software. For more information, refer to the User's Guide listed in Table 2 on page 15.

If the sensor value is outside of the maximum or minimum values, or it has altered more than the maximum step change allowed, then data will be flagged as INVALID. Invalid data is typically displayed as ///// (this is a user settable parameter). If a sensor displays invalid data, this is an indication that the sensor is faulty or out of calibration, or there is a problem in powering or measuring the sensor.

The LASTVAL Command

If the value in the report changes to ////, you can check the measurement's value with the **LASTVAL** command. Give the command in the terminal connection. When you use the raw parameter, the measured value before any validation and the status produced during validation are shown. When you use the corresponding signal name, the validated value is shown.

LASTVAL [Measurement] [raw | Signal name]

where

Measurement	=	The name of the measurement as it is defined in the MAWS setup file.
raw	=	The parameter that gives the status and the value of the measurement before validation.
Signal name	=	The parameter that gives the validated value of the measurement.

Example:

The measurement TAMeasQMH101_1 is defined in the setup file. The command with the raw parameter produces the following response:

```
/ > LASTVAL TAMeasQMH101_1 raw
Status:1  Value:20.490570
```

where

Status:1	=	The value is valid.
Value:20.490570	=	The raw value for the temperature measurement is 20.49xxxx

When the value in the report changes to ////, you can check the value. In the following case the probe is not connected:

```
/ > LASTVAL TAMeasQMH101_1 raw
Status:2  Value:-238.285549
```

where

Status:2	=	The value is invalid.
Value: -238.285549	=	The raw value for the temperature measurement is -238.285549, which means the probe is not connected.

The command with the signal name parameter (in the following case TA) produces the following response:

```
/ > LASTVAL TAMeasQMH101_1 TA
Status:1  Value:20.490570
```

where

Status:1	=	The value is valid.
Value:20.490570	=	The validated value for the temperature measurement is 20.49xxxx

Software Operation

After MAWS has been without power (for example when you start it for the first time), check the time and date. The timed operations will not work if the correct time is not set!

NOTE	The time and date must be set if the backup battery has been disconnected.

There may be some problems if you see either of these prompts:

```
/ E>
/ W>
```

/ E> means that there are errors and / W> means that there are warnings.

It is normal to have one or two warnings after the serial connection to MAWS has been reset, for example, you have turned your PC off and so it is nothing to be worried about.

To see active warnings, type **warnings**. To clear active warnings, type **warnings clear**. Warnings indicate that there are some problems in the software.

Example:

```
/ W> warnings

Warning: Break
  occurred 9 times first in uart.cpp[84]
  during thread: 00019F60 [AbsTimerT]
  object pointer: 106C [component: COM0]

Warning: Frame
  occurred 14 times first in uart.cpp[83]
  during thread: 00019F60 [AbsTimerT]
  object pointer: 106C [component: COM0]
```

The Break and Frame warnings mean that most likely you have turned your PC off and on again. This causes no trouble and you can clear the warnings.

```
Warning: Device reset
  occurred 1 times first in
c:/libs/MAWS/adcl/kernel/idle.cpp[52]
  during thread: 00001694 [Idle]
  object pointer: 163C [component: Idle]
```

The warning above means that you have reset MAWS. This causes no trouble and you can clear the warning. If you have not reset MAWS and the warning still occurs, contact Vaisala technical support (see section Getting Help on page 159).

```
Warning: Data missing
  occurred 2 times first in
h:/MAWS/software/adcl/report/confrep.cpp[414]
  during thread: 00019C0C [AbsTimerT]
  object pointer: 33A94 [component: MyRep1]
```

If you receive this warning, check that **sname**, **pslevel**, and **altitude** are set.

To see active errors, type **errors**. To clear active errors, type **errors clear**. Errors indicate that there is something wrong with the sensors or configuration. Write down the error information and contact technical support.

Table 30 Some Common Problems and Their Remedies

Problem	Probable Cause	Remedy
MAWS will not open for commands.	The terminal connection is not open.	Type **open** and press ENTER. The command must be typed exactly right before it can be executed.
		Correct PC port and MAWS COM port settings and check the cable connection.
	MAWS is not receiving power.	Check connections and power supply. Check that the internal battery is connected.
MAWS is not sending anything (nothing is seen on the screen).		Press and keep down the reset button for a few seconds. MAWS will restart and display the text "Using blank configuration".
		Check your setup and upload it again to your MAWS.
After reset, MAWS displays "!Erroneous setup file".	The Setup file does not exist in Cfg directory.	Copy or load the file to the correct directory.
	Setup file is not executable.	Type "chmod *Filename* rwx".
Nothing happens during the Zmodem transfer.	The terminal connection has failed.	Type CTRL+X (hold CTRL down and press X) five times.
After uploading a new setup file, MAWS Terminal displays "Unhandled exception number: 39".	Setup might include too many calculations, the statistical calculations may be too long, or the intervals between the statistical calculations too short.	To solve the problem, consider removing some calculations, or executing the calculations less frequently. You might, for example, avoid calculations which are executed more frequently than the results are reported or logged.
		Purchase the memory expansion card, it contains additional 512 kB RAM memory.

System Information

You can acquire a report that contains system information by using the **SYSINFO** command in MAWS Terminal. The command lists many parameters that are useful especially when troubleshooting the system or when contacting Vaisala HelpDesk.

Example:

```
/ > SYSINFO

Serial #         : 59289091
Hardware         : Rev F
Software         : 3.02    Checksum  : 61577576
System RAM       : 1024kB
Free memory      : 583kB
Internal temp.   : 3.13'C
Active errors    : NO
Active warnings  : NO
Piggyback - 0    : DSU232 rev: B serial no: 009513
Piggyback - 1    : N/A
Extension board  : QMC102 rev: B serial no: V37306
System uptime    : 65h 20min 27sec since Fri Jan 11
16:35:39 2002

/ >
```

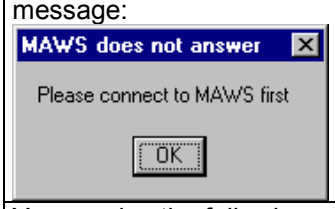
where:

Serial #	=	The serial number of the logger PCB.
Hardware	=	The hardware revision of the logger PCB.
Software	=	The software version for the operating software and it's checksum.
System RAM	=	The total amount of the memory on the logger.
Free memory	=	The amount of the free memory on the logger.
Internal temp.	=	The internal temperature of the logger.
Active errors	=	The existence of the active errors: YES/NO
Active warnings	=	The existence of the active warnings: YES/NO
Piggyback - 0	=	The type and serial number of the additional module installed in the module slot 1.
Piggyback - 1	=	The type and serial number of the additional module installed in the module slot 2.
Extension board	=	The type and serial number of the optionally installed memory expansion board.
System uptime	=	The total time that the system has been running, calculated from the last reset.

Connection Problems

If you cannot connect to MAWS, the service connection is not opened and you cannot work with MAWS. In case of connection problems, check Table 31 on page 157.

Table 31 Some Common Connecting Problems and Their Remedies

Problem	Probable Cause	Remedy
You receive the following message: 	You are trying to connect to a wrong port.	Select the Address book option from the Settings menu to check the port numbers.
	Cables are not connected.	Check that the modem cable is connected properly.
You receive the following message: 	You are trying to connect to a port that does not exist in your computer.	Check the port settings.
	The port is reserved (some other program is connected to it).	It is possible, that you have opened the MAWS Terminal, minimized the window and forgotten you have already opened it, and then tried to open the program again.
You do not receive any messages.	Cables are not connected.	Connect the cables as shown in section Establishing Terminal Connection on page 104.

Commands

When typing commands, you may encounter some error messages. The following table will explain the most typical messages.

Table 32 Error Messages

Error Message	Probable Cause	Remedy
Error: Executable not found	Typing error.	Correct typing.
Syntax error!	Typing error: non-acceptable characters, e.g. '+	
Error: Directory not found	Typing error in directory name.	
Error: Wrong number of parameters	A missing or extra parameter.	Check the command syntax (help *command*) and give the command again.
Error: Missing parameter	A missing parameter.	

Battery Status

You can view battery status information by giving the command **battery** without parameters.

Example:

```
/ > battery
Remaining=100
State=FLOAT_CHARGE
U=6.850195
I=2.685547
Type=PB_BATTERY
Capacity=1.200000
Ext.DC=8.132420
Internal temperature=23.511668
```

Battery voltage (U) and voltage at the +ExtDC terminal are given as volts, charging current (I) as milliamperes and capacity as ampere-hours. The remaining percentage shows how much energy is left in the battery.

When is suspected that the internal battery or the charging circuitry is defective, try the following:

- Check that the battery capacity is correct and change it with **battery <capacity>** command, if necessary. If the capacity setting is too low, the battery simply charges slowly. In the opposite case, the battery may be damaged due to too high charging.
- Check the battery voltage, ExtDC voltage and charging current. ExtDC should be higher than battery voltage for charging. If it is lower, battery is discharging and charging current shows negative value. Normally, battery voltage should vary between 5.8 and 7.0 volts and it may rise as high as 7.5 volts during Quick Charge (for lead batteries).

Determining MAWS Operation Mode

You can look at the status LED to determine the MAWS operation mode. The LED is located on the MAWS logger board (see Figure 4 on page 24). First, you have to open the tube as instructed in section Installing MAWS Basic Components on page 53.

Table 33 Determining Operation Mode by LED Flashing

LED flashing interval	Operation mode	Note
All the time	MAWS has been reset but setup has not been examined yet.	
Once per 5 seconds	Setup running.	
Once per 10 seconds	Blank boot or configuration cannot be run.	
Quickly 2 times	Setup is running but there are warnings.	Interval determined by setup.
Quickly 3 times	Setup is running but there are errors.	Interval determined by setup.
Not at all	None.	Check the power supply!

Power Supply

Solar Panel

Table 34 Troubleshooting the Solar Panel

Problem	Probable Cause	Remedy
The power output has decreased.	The module surface is dirty	Gently clean it with a soft cloth or sponge using water and mild detergent.

Getting Help

Contact Vaisala technical support:

E-mail helpdesk@vaisala.com

Telephone +358 9 8949 2789

Fax +358 9 8949 2790

Return Instructions

In case MAWS needs repair, please follow the instructions below to speed up the process and avoid extra costs.

1. Read the warranty information.
2. With the returned component(s), write a Problem Report with name, e-mail, telephone number, and fax number of a technically competent person, who can give additional information about the problem.
3. On the Problem Report, please explain:
   - What failed (what worked / did not work)?
   - Where did it fail (location and environment)?
   - When did it fail (date, from the beginning / after a while / periodically / randomly)?
   - How many failed (only one defect / other same or similar defects / several failures in one unit)?
   - What was connected to the product and to which connectors?
   - Input power source type, voltage and list of other items that were connected to the same power output (lighting, heaters, motors etc.)?
   - What was done after the failure was noticed?
4. Include a detailed return address with your preferred shipping method on the Problem Report.
5. Pack the product using good quality ESD protection bag with suitable cushion material in a strong box of adequate size to prevent any shipping defects.
6. Include the Problem Report in the same box with the returned product.
7. Send the box to:
   Vaisala Oyj
   Contact person / Division
   Vanha Nurmijärventie 21
   FIN-01670 Vantaa
   Finland

CHAPTER 7

TECHNICAL DATA

This chapter provides the technical data of MAWS and its sensors.

Connector Block Descriptions

The MAWS logger includes:

1. Ten measurement channels and one internal channel for pressure measurement.
2. One connector block for power supplies.
3. One connector block for communication channel.
4. Two blocks for optional communication modules.

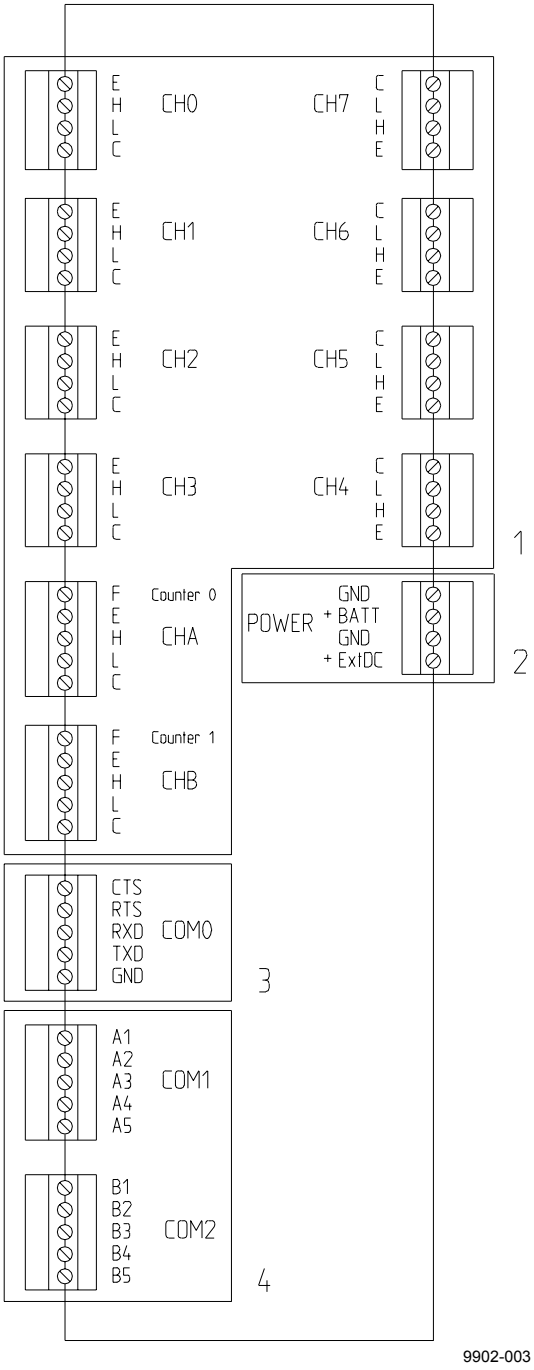


Figure 120 Connector Blocks

Single-ended (H-C or L-C) or differential (H-L) measurements can be performed in the 10 measurement channels.

Table 35 Description of Analog Measurement Channels

Channels	Pin name	Description
CH0, CH1, CH2, CH3 16-bit ADC	E	12 V / 25 mA voltage excitation ON/OFF, voltage can be measured. OR: 100µA/1mA current excitation.
	H	Analog input (High)
	L	Analog input (Low)
	C	The pin has been connected to ground (GND) via a 10 ohm resistor so the current can be measured.
CH4, CH5, CH6, CH7 16-bit ADC	E	100µA/1mA current excitation
	H	Analog input (High)
	L	Analog input (Low)
	C	Common return and reference level for voltage measurements via the channel's own E-, H- and L-pins. The pin has been connected directly to ground.
CHA, CHB Suitable for fast-changing input signals 12-bit ADC	F	Frequency input
	E	0-12 V /20 mA adjustable excitation voltage, can be measured.
	H	Fast analog input (High)
	L	Fast analog input (Low)
	C	Common return (Analog ground)

NOTE Each sensor of the basic configuration has its own dedicated channel. The table above is for reference purposes only.

Table 36 Description of the Power Channel

Pin name	Description
GND	Ground
+BATT	5 ... 10 V
GND	Ground
+ExtDC	8 ... 16 V

Wiring Diagrams

For the basic set of sensors, the wiring has been done at the factory according to Figure 121 on page 164. Do not change the wiring between the connectors and logger pins. For special deliveries, a separate wiring diagram is supplied in order to help you connect the sensor wires to correct connectors. The numbers next to the plug connectors indicate poles for connection wires.

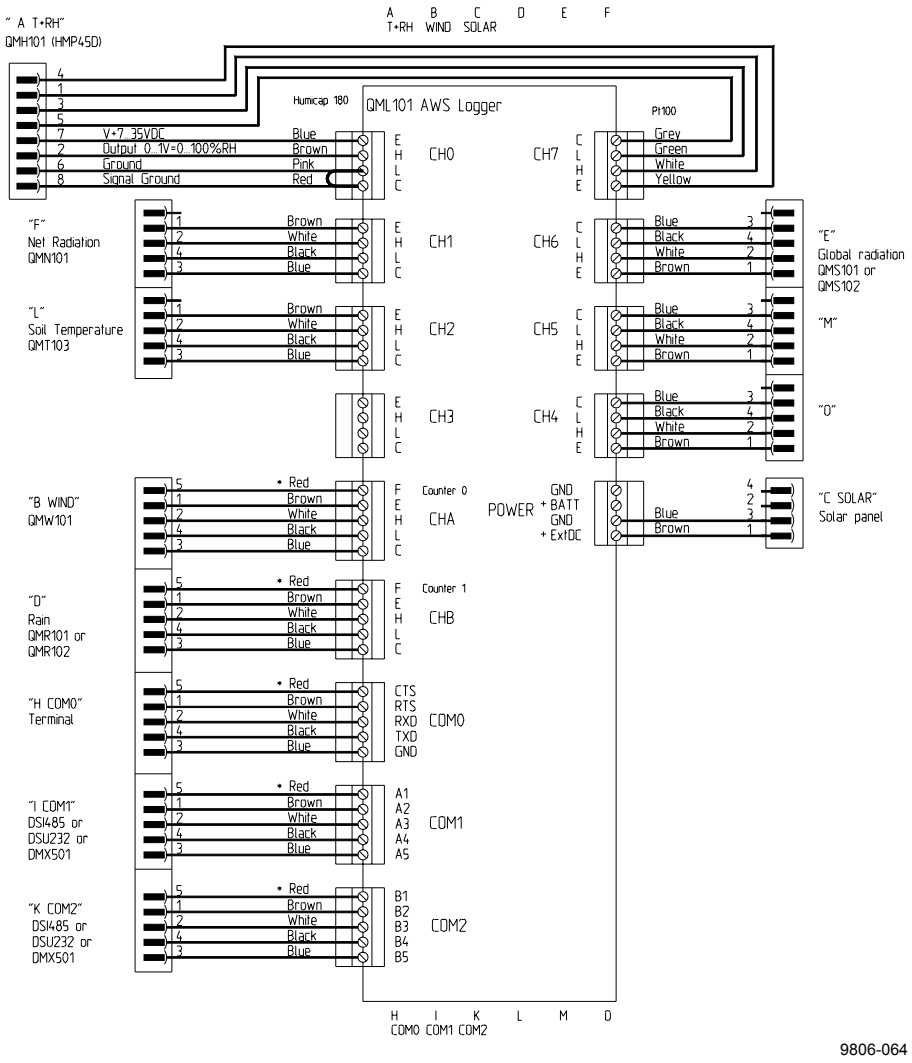


Figure 121 Basic Wiring Diagram

DSU232

The DSU232 is an unisolated RS-232 module that will provide either a double serial channel without handshaking or a single RS-232 with handshaking. It can also feed 12 V (45 mA) for a serial sensor, when used in sensor mode.

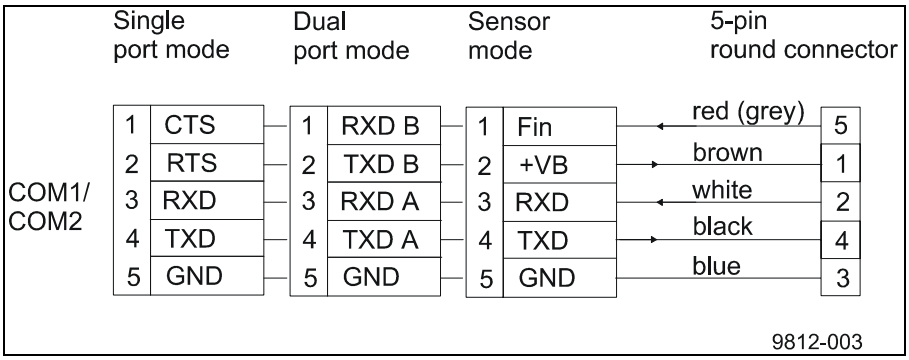


Figure 122 DSU232 Wiring Diagram

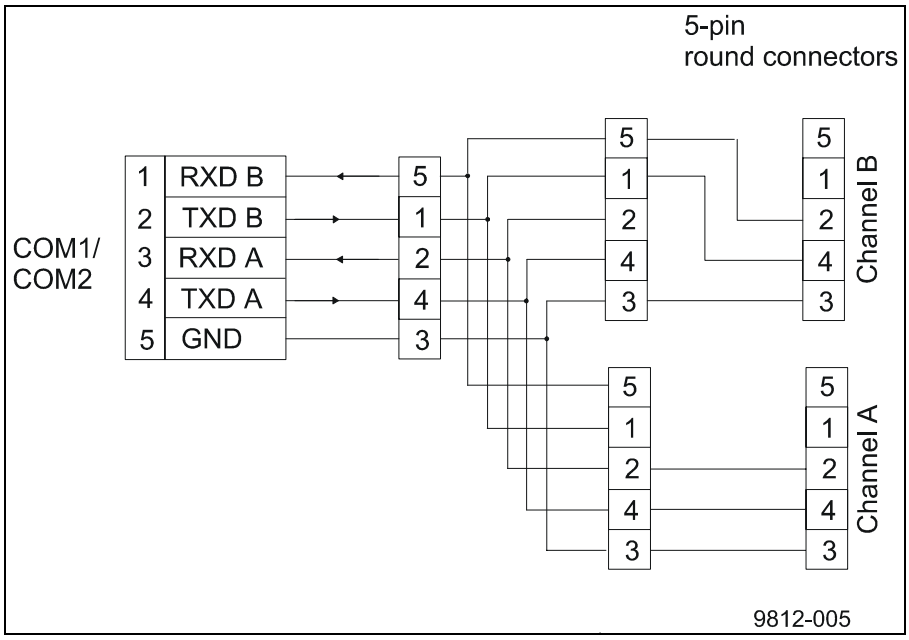


Figure 123 Suggested T-connection in Dual Port Mode

DSI485A

The DSI485A communication module can be configured for either 2-wire line or for 4-wire line when receive and transmit lines are separated. If the module is configured for a 2-wire line, the transmitter is enabled only during the transmission. Normally, the 2-wire connection is used to connect several devices to the same communication line. The 4-wire mode is a default mode.

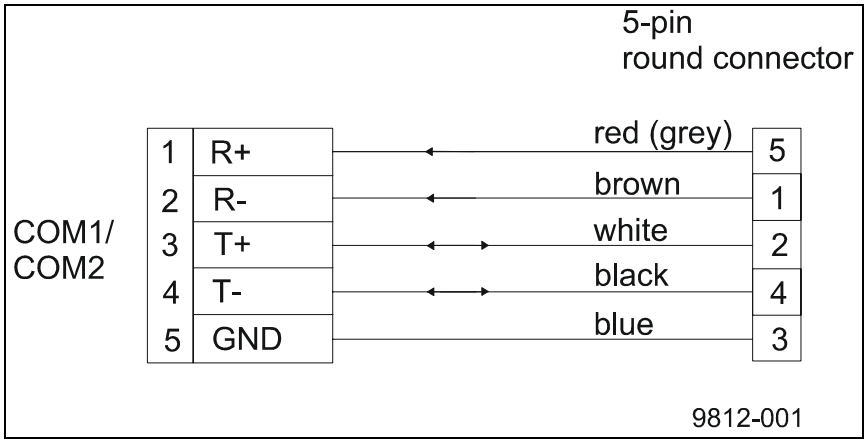


Figure 124 DSI485A Wiring Diagram

NOTE	In 2-wire mode, only T+ and T- pins are used.

DSI486

Channel A is always used in RS-485 -mode. In 2-wire RS-485, both transmitted and received data is sent via this channel. In 4-wire RS-485 this channel can either transmit or receive depending on the configuration. Jumper X4 defines the line terminating resistor for the data channel A. Remove the jumper X4, if you do not need the terminating resistor of DSI486. Figure 125 below provides a schematic wiring diagram.

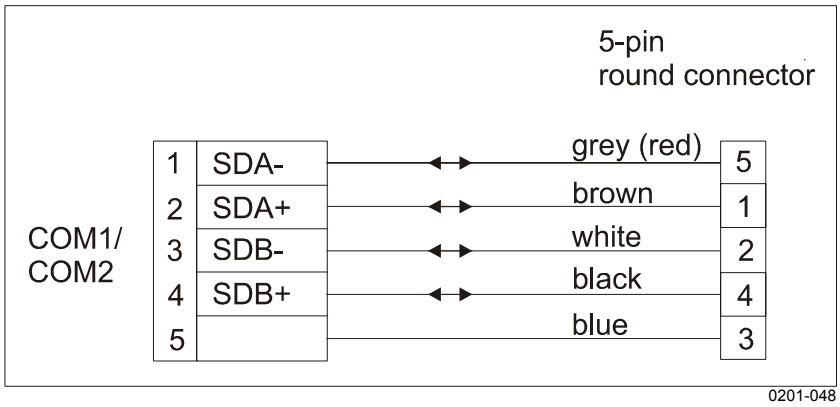


Figure 125 DSI486 Wiring Diagram for Dual RS-485

Channel B can be used either in the RS-485 mode or in the RS-232 mode. In 2-wire RS-485, both transmitted and received data is sent via this channel. In 4-wire RS-485, this channel can either transmit or receive depending on the configuration.

Figure 125 on page 166 provides a schematic wiring diagram for the dual RS-485 connection, the dual 2-wire connection utilizing both channels. The correct jumper settings for the channel B are listed in Table 37 below. The jumpers are located on the module as illustrated in Figure 126 below.

Table 37 The Jumper Settings for Channel B in the RS-485 Mode

Jumper	Connected Pins	Function
X3	1-2	Sets the RS-485 mode active for the channel B.
	3-4	
X6	1-2	
X5	1-2	The line terminating resistor is in use with RS-485.

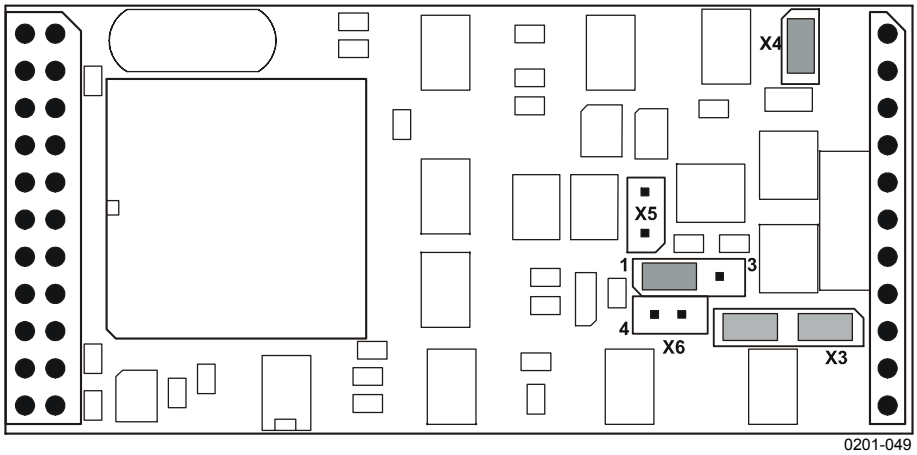


Figure 126 DSI486 Default Jumper Locations

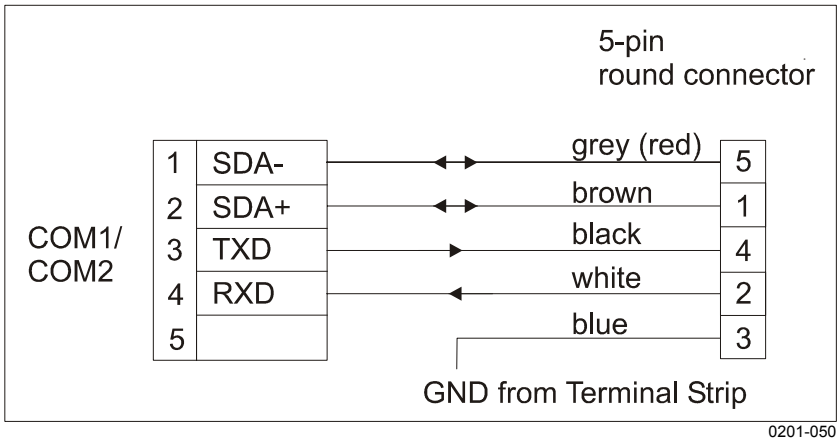


Figure 127 DSI486 Wiring Diagram for RS-485 and RS-232

Figure 127 on page 167 provides a schematic wiring diagram for the combination of the RS-485 and RS-232 connection. The correct jumper settings for the channel B are listed in Table 38 below.

Table 38 The Jumper Settings for Channel B in the RS-232 Mode

Jumper	Connected Pins	Function
X3	2-3	Sets the RS-232 mode active for the channel B.
X6	1-4	
	2-5	
X5	None	The line terminating resistor is not in use at all.

DMX501

The DMX501 modem module can be configured for point-to-point line or for a multidrop modem network. If a modem is configured for multidrop use, the outgoing carrier is valid only during transmission. If MAWS is the master in the multidrop network, DMX501 can be normally configured for point-to-point use.

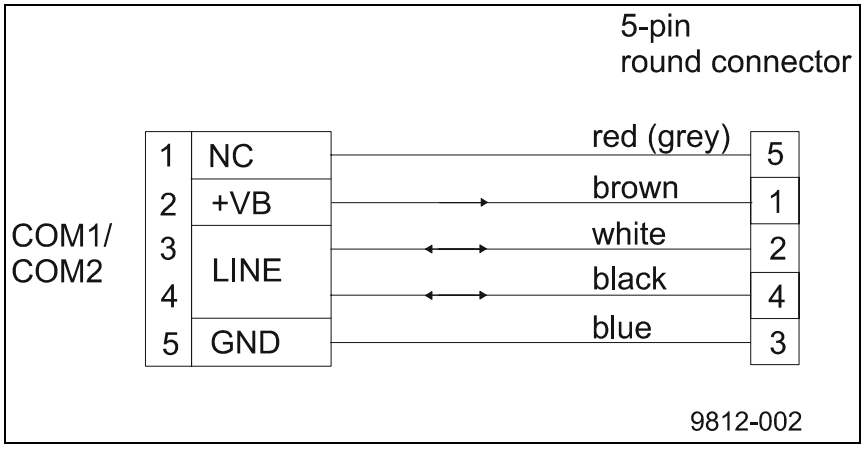


Figure 128 DMX501 Wiring Diagram

Connectors

QMT107

Pin numbers in Table 39 below refer to Figure 129 below.

Table 39 Cable wire connections

Signal	Connection Pin in Standard Cable		Connector L (CH2) default in MAWS
	Color	Pin No	
GND	Blue	3	C
Low out	Black	4	L-
VCC	Brown	1	E
High out	White	2	H+

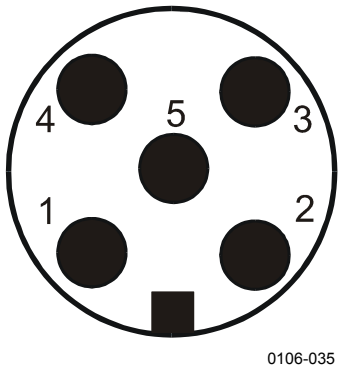


Figure 129 Connector of QMT107 (Viewed from Connecting Side)

VCC is a power supply from 6 to 30 VDC, which draws a maximum of 1.5 mA. This signal should be connected to the sensor excitation pin of the data logger. GND is common ground for VCC.

Pins High out and Low out, provide differential measurement signals from the probe. These signals should be connected to the data logger's high impedance differential input (>1 MΩ).

Battery Charging

The QML102 data logger has an internal battery charger circuitry that has a programmable charging voltage of 4.5 to 9.9 V and four selectable current limits 100 mA, 300 mA, 500 mA, and 700 mA. Charging voltage and charger input voltage (+ExtDC) can be measured with 1 % accuracy and charging current can be measured

with 5 % accuracy. The charger is protected against reverse input voltage and temperature. In addition, it has internal reverse current blocking to facilitate using solar cells without a blocking diode.

The MAWS charger is capable of handling 6 V lead batteries from 1.2 Ah up to 24 Ah. Due to its limited current capability, it cannot quick charge larger than 6 Ah batteries.

Power Supply and Battery Types

Battery Sensing

When QML102 first starts or resets, it tries to sense the battery type that is connected to its internal battery connector (4-pin header connector at PCB near POWER connector). This connector has two sense pins that are used by charger software to automatically detect the type of the connected battery.

External Power Supply

The external DC supply is always connected to POWER connector pins +ExtDC and GND. The external power supply can be either regulated or unregulated DC supply (8 ... 30 V) or a solar cell if internal battery is present. To avoid excessive heating, 8 ... 16 V is recommended.

The required current capability depends considerably on the MAWS configuration. If there are no optional sensors or other add-ons (radios, modems, etc.) that require constant powering and measurement intervals are long (1 minute or more for humidity, temperature, and pressure), even a few dozen milliamperes are enough to keep the system alive and slowly charge the battery. If there is no internal battery, then at least 200 mA capability is recommended to avoid resetting due to possible current peaks. If the quickest possible battery charging is required, then a 1A power supply is recommended.

NOTE The condition, when external DC supply is used without an internal battery, is automatically detected. In this case, the charger sets its output voltage to 9.9 V to enable maximum efficiency and minimum current consumption from supplies of 12 VDC or higher.

Solar Cell

When the solar cell is used as an external power supply, a few things should be kept in mind:

- Always use solar cell in combination with lead battery.
- To achieve the highest possible efficiency, a 6 to 8 V solar cell is recommended.

NOTE You can use a 12 V solar cell, however, half of the delivered energy is lost as heat in the linear charger regulator.

Lead Batteries

The charger is capable of charging from 1.2 to 24 Ah, 6 V lead acid batteries. There is room for one 1.2 Ah or 1.3 Ah battery in the logger battery compartment. If larger capacity is required, additional batteries must be connected to the POWER connector terminals GND and +BATT. Internal and external batteries can be present at the same time; they are essentially paralleled. For protection, an automatic self-recovering fuse is used.

CAUTION The battery protection fuse may trip if internal and external batteries have very different charge states when connecting them. This is due to current flowing from one battery to the other. This condition ceases, when the battery voltages reach a balance after one or several trip-recover cycles.

To be able to efficiently charge the lead battery, the charger must know the total capacity of the connected lead batteries. This capacity setting is done with the command:

battery [capacity]

Where capacity is the battery capacity in Ah. This value is also saved as a static parameter and is not lost if QML102 is reset or unpowered.

CAUTION If too large of a capacity value is used, the battery may be permanently damaged due to excessive charge current.

Primary Cells

Primary (non-rechargeable) cells from 6 to 9 V are most suitable for use with QML102. The standard battery alternative for MAWS is a dual cell lithium battery that has nominal voltage of 7.2 V, 35 Ah capacity and a very wide temperature range. Common alkaline cells (4 to 6 cells in series) in a suitable battery holder can be used as well.

These batteries do not generally fit into QML102 internal battery compartment so they have to be connected to the POWER connector terminals GND and +BATT.

NOTE	Short pins 3 and 4 in QML102 internal battery connector with jumper or preferably use a special pin header for correct battery type sensing.

If the primary cell setting is detected, the charger circuitry of QML102 is completely shut off to protect the battery from reverse currents.

CAUTION	Never connect voltages higher than 10 V between terminals +BATT and GND as this may damage the QML102 electronics.

Lead Battery Charger Operation

The charger has three operating modes when a lead battery is detected: Normal Charge, Quick Charge and Float Charge. When MAWS starts, it first checks the battery type and if lead is found the charging task starts and is performed once a minute.

NOTE	If the internal temperature of the QML102 is found to be below -20 °C, the charging current is limited to 100 mA regardless of the battery capacity.

Normal Charging

At first, the charging task always enters Normal Charging mode. In Normal Charge, charging voltage is set to 6.85 V corrected with temperature coefficient. Charging current is set to 300 mA, 500 mA, or 700 mA depending on battery capacity.

If the battery is accepting certain amount of charging current and there is enough energy available at +ExtDC input, the charging task enters Quick Charge mode. In the opposite case, when the charging current drops below 0.0075 CA even if more energy would be available, the charging task enters Float Charge mode.

If the battery is discharging (charging current is negative), the charging task always enters Normal Charge mode.

NOTE After powering up or reset, it takes several minutes to calculate the remaining capacity of the battery if the charger remains in Normal Charge mode.

Quick Charging

The purpose of the Quick Charge mode is to fill the battery as quickly as possible using a specified quick charge voltage for lead batteries. In Quick Charge, charging voltage is set to 7.35 V corrected with temperature coefficient. Charging current is typically the same or one step higher as in Normal Charge mode.

NOTE Quick charging is not fully possible for batteries having more than 6 Ah capacity, due to the limited maximum current of the QML102 charger.

When the charging current drops below 0.075 CA, the charger task enters Normal Charge mode. It also sets the remaining capacity to 90 % if current dropping was caused by battery filling up rather than missing energy at +ExtDC terminal.

During Quick Charge, the remaining capacity can be reliably estimated only after a certain amount of time. This is when the charging voltage has reached the limit and the current has started to decrease. At this point, the remaining capacity is roughly 60 %. Normally, this point should be reached within two hours if the battery was completely empty.

NOTE If an empty battery (with a voltage less than 5.5 V initially) starts charging and reaches the 60 % limit very quickly (or does not even Quick Charge), it is probably damaged and should be replaced to ensure reliable operation.

Float Charging

When the charger task enters Float Charge mode, the battery is considered to be full and the remaining capacity is set to 100 %. Charging voltage is set to 6.85 V corrected with temperature coefficient. Current limit is always 100 mA in Float Charge.

If the battery starts to discharge, the charger task enters Normal Charge mode.

Temperature Protection

The charger protects lead batteries from extreme temperatures by limiting the charge current or shutting the charger completely off under certain conditions. This helps to prolong expected battery life.

If QML102 internal temperature rises higher than +50 °C, the charger shuts completely off and battery status shows "CHARGE_OFF". Note that the battery manufacturers strictly forbid charging of their Lead batteries above +50 °C.

When logger temperature drops below -20 °C, the charging current is limited to 100 mA to avoid unnecessary gas generation. Lead type batteries do not accept charging energy well at low temperatures. They lose the excess energy by generating gas. This may shorten battery life. Normally, 100 mA limit should not cause any problems as the average current consumption of QML102 is much lower.

Specifications

QML102 Logger

Table 40 QML102 Logger Specifications

Property	Description/Value
Processor	32 bit Motorola
A/D conversion	16 bit
Data logging memory	1.7 Mbytes internal Flash memory Up to 160 Mbytes on optional Compact Flash memory card.
Sensor inputs	10 Analog inputs (20 single ended inputs) 2 counter / frequency inputs Internal channel for PMT16A pressure transducer
Typical accuracy across measured temperature range -50 °C ... +80 °C	Better than ± 0.06 °C
Maximum error across measured temperature range -35 °C ... +50 °C	Less than ± 0.12 °C
Maximum error at 0 °C	Less than ± 0.06 °C
Voltage measurement ±2.5V range ±250 mV range ±25 mV range ±6.5 mV range	 Better than 0.08 % F.S. ± 150 µV Better than 0.18 % F.S. ± 15 µV Better than 0.18 % F.S. ± 3 µV Better than 0.18 % F.S. ± 3 µV
Frequency measurements	0.003 % + resolution 241 ns (up to 2 kHz)
Common mode range	+5 V / -4 V
Real-time-clock Standard	 Better than 20 sec/month
Serial communication Standard Optional Speed Parameters	 One RS-232 Two optional plug-in slots for communication modules for increasing the number of serial I/O channels up to 5 pcs 300 ... 19200 bps Configurable speed, start bits, data bits, stop bits, parity, XON/XOFF, and check sum
Voltage (external powering)	8 ... 14 VDC recommended (30 V max.)
Standard internal battery	1.3 Ah/6 V
Power consumption	< 10 mA/6 V (typically with basic 5 sensors)
Temperature (operating)	-35 ... +55 °C
Temperature (storage)	-50 ... +70 °C
Humidity	0 ... 100 % RH
Emissions	CISPR 22 class B (EN55022)
ESD immunity	IEC 61000-4-2
RF field immunity	IEC 61000-4-3

Property	Description/Value
EFT immunity	IEC 61000-4-4
Surge (lightning pulse)	IEC 61000-4-5
Conducted RF immunity	IEC 61000-4-6

Accessories

Table 41 SOLAR6 Solar Panel Specifications (MAWS201)

Property	Description/Value
Peak power (Pp) @ 1 kW/m^2 @ + 25 °C	6 W
Voltage @ peak power (Vpp)	8.3 V
Current @ peak power (Ipp)	0.72 A
Short-circuit current (Isc)	0.8 A
Dimensions (l x w x d), in mm	346 x 268 x 5
Weight, incl. mounting accessories	2.8 kg
Output cable	0.9 m, connector included

Table 42 SOLAR6-75 Solar Panel Specifications (MAWS101)

Property	Description/Value
Peak power (Pp) @ 1 kW/m^2 @ + 25 °C	6 W
Voltage @ peak power (Vpp)	8.3 V
Current @ peak power (Ipp)	0.72 A
Short-circuit current (Isc)	0.8 A
Dimensions (l x w x d), in mm	346 x 268 x 5
Weight, incl. mounting accessories	3.0 kg
Output cable	6 m, connector included

Table 43 SOLAR12 Solar Panel Specifications (QMP201C)

Property	Description/Value
Peak power (Pp) @ 1 kW/m^2 @ +25 °C	12 W
Guaranteed min. peak power	10.8 W
Voltage @ peak power (Vpp), typical	16.7 V
Current @ peak power (Ipp), typical	0.72 A
Short-circuit current (Isc), typical	0.8 A
Temperature coefficient of current	0.25 mA/°C
Operating temperature	-40 °C ... +85 °C
Dimensions (in mm)	268 × 540 × 15
Weight	1.5 kg
Output cable	6 m, 2 × 1.55 mm^2, incl.

Table 44 7 Ah Backup Battery Specifications (inside QMP201C)

Property	Description/Value
Type	Sealed. Lead-acid
Nominal voltage	12 V
Nominal capacity	7 Ah
Self discharge	3% / month
Expected lifetime	4 … 5 years
Dimensions	151 (w) × 65 (d) × 97.5 (h) mm
Weight	2.8 kg

Table 45 QBR101 Battery Regulator Specifications (inside QMP201C)

Property	Description/Value
Maximum input voltage (SMPS and Solar Panel inputs)	30 VDC
Maximum input current (SMPS)	6 A
Solar panel input	55 W max.
Recommended input voltage from SMPS input	16 VDC
Max. load current (backup output)	3.5 A
Recommended battery capacity range	4 … 72 Ah
Battery charge current for 4 Ah battery (selections 0.5 / 1.0 / 2.0 / 2.5 A)	0.5 A
Max. battery discharge current	3.5 A
Battery charge voltage selection (with external resistor)	13.7 V
Battery charge temp. comp. Coefficient	-20 mV/°C typ.
Load disconnection threshold voltage (with Lo Btry Switch)	10.0 V typ.
Load reconnection threshold voltage	12.0 V typ.
Btry Low signal threshold voltage	11.5 V typ.
Self consumption from battery (with LEDs disconnected)	0.2 mA max. @ +25 °C
Ground connection	Negative
Reverse voltage protection	Battery, solar panel
Dimensions (in mm)	90 × 80 × 25 (w × d × h)
Weight	0.1 kg
Housing	Anodized aluminum, gray
Wire terminals - battery and load wires - solar panel, DC input, and controls	Screw terminals, removable 2.5 mm^2 1.5 mm^2
MTBF (parts stress method, MIL.HDBK 271F ground benign Ta +25 °C)	> 150 000 hours

Table 46 BWT15SX Mains Power Supply Unit Specifications (inside QMP201C)

Property	Description/Value
Output power	30 W
Operating principle	SMPS
Input voltage range	85 … 264 VAC
Frequency range	47 … 440 Hz
Input current on full load: 110 VAC 220 VAC	 0.6 A 0.4 A
Output voltage	+15 V, adjustable ± 10%
Output current	2 A
Efficiency	80 %
Noise, ripple, and spikes	± 1 % + 50 mV_{p-p}, max.
Input regulation effect 85 … 264 VAC	± 0.8 % max.
Load regulation effect 0 … 2 A	± 0.9 % max.
Temperature coefficient	± 0.03 %/°C
Output voltage rise time	200 ms max. at +25 °C
Hold-up time	20 ms min. at +25 °C
Over current protection	Fold-back, automatic recovering
Switching frequency (110V/230V)	50 kHz / 80 kHz
Electrical strength/ isolation: Input - Output Input - Chassis Output - Chassis Input - Output - Chassis resistance	 3 kV AC, 1 minute 2.5 kV AC, 1 minute 500 V AC, 1 minute 50 MΩ minimum
Leakage current	0.75 mA max.
Operating temperature range	-40 ... +60 °C
Weight	250 g (chassis included)
Approvals	UL 1950 CSA 234 (IEC 950) VDE805 EN 60959 (IEC 950) CE - EMC 89/336 EEC - LVD 73/23 EEC

Sensors

Wind Sensors

Table 47 QMW101/QMV110 Combined Wind Sensor Specifications

Property	Description/Value
Measurement range	0.5 ... 60 m/s (anemometer) 0 ... 360 ° (vane)
Accuracy (anemometer)	± 0.3 m/s (< 10 m/s) < 2 % (> 10 m/s)
Accuracy (vane)	< ± 3 °
Threshold	< 1.0 m/s
Distance constant (anemometer)	2 m
Delay distance (vane)	0.6 m
Operating temperature range	-40 ... +55 °C
Dimensions (h × w)	265 × 360 mm
Weight	360 g

Air Temperature and Relative Humidity Sensor

Table 48 QMH101 Air Temperature and Relative Humidity Sensor Specifications

Property	Description/Value
Range (Temperature)	-40 … +60 °C
Range (RH)	0 ... 100 %
Accuracy (Temperature)	< ± 0.3 °C
Accuracy (RH)	± 2 %, 0 ... 90 % ± 3 %, 90 ... 100 %

Pressure Sensor

Table 49 PMT16A Pressure Sensor Specifications

Property	Description/Value
Accuracy	± 0.3 hPa incl. one year drift (with factory calibration)
Pressure range	600 ... 1100 hPa
Temperature range	-40 ... +60 °C (operating)

Precipitation Sensors

Table 50 QMR101 Rain Gauge Specifications

Property	Description/Value
Sensor/transducer type	Self-emptying tipping spoon/magnet
Funnel diameter	159.6 mm
Orifice (opening area)	200 cm^2
Sensitivity	0.2 mm
Capacity	144 mm/h
Accuracy < 24 mm/h < 120 mm/h	 < ± 5 % < ± 10 %
Material	UV stabilized plastic
Cable	Included
Weight	380 g

Table 51 QMR102 Rain Gauge Specifications

Property	Description/Value
Sensor/transducer type	Tipping bucket/reed switch
Funnel diameter	254 mm
Orifice (opening area)	500 cm^2
Sensitivity	0.2 mm
Capacity	120 mm/h
Accuracy < 24 mm/h < 120 mm/h	 < ± 1 % (weather dependent) < ± 5 %
Material	UV stabilized plastic
Cable	6 m
Weight	1000 g (w/o installation plate)

Solar Radiation Sensors

Table 52 QMS101 Global Solar Radiation Sensor Specifications

Property	Description/Value
Sensitivity	100 µV/W/m^2 (nominal)
Spectral response	Equals silicon
Operating temperature	-30 ... +70 °C
Response time	< 1 second
Range	2000 W/m^2
Temperature dependence	+0.15 %/°C
Directional error	< 10 %
Spectral range	0.4 ... 1.1 micron

Table 53 QMS102 Global Solar Radiation Sensor Specifications

Property	Description/Value
Maximum irradiance	2000 W/m^2
Spectral range	305 ... 2800 nm (50% points)
Sensitivity	10 ... 35 µV/W/m^2
Impedance	79 ... 200 Ω
Response time	18 seconds (95 %)
Non-linearity	± 2.5 % (< 1000 W/m^2)
Temperature dependence of sensitivity	6 % (-10 ... +40 °C)
Operating temperature	-40 ... +80 °C
Zero-offset due to temperature changes	< 4 W/m^2 @ 5 K/h temp. change
Tilt response	< ± 2 %
Signal output (atmospheric condition)	0 ... 50 mV
Field of view	180°
ISO class	Second class
Cable length	10 m

Table 54 QMN101 Net Solar Radiation Sensor Specifications

Property	Description/Value
Spectral response	0 ... 100 µm
Detector protection	Teflon coated (no domes)
Sensitivity (upper detector)	10 µV/W/m^2 (nominal)
Recommended output range	-25 ... +25 mV
Sensor asymmetry	20 %
Range	-2000 ... +2000 W/m^2
Response time (1/e)	20 s (nominal)
Operating temperature	- 30 ... + 70 °C
Directional error	< 30 W/m^2 (0 ... 60° @ 1000 W/m^2)
Stability	< ± 2 % per year
Non-linearity	< 1 % up to 2000 W/m^2

Soil Temperature Sensors

Table 55 QMT103 Soil/Water Temperature Sensor Specifications

Property	Description/Value
Sensor Type	Pt-100 type RTD element
Performance (accuracy)	Better than +0.08 °C at 0 °C, conforms to 1/4 DIN 43760B
Sensitivity	0.385 Ω/°C (DIN 43760)
Measuring range	- 50 ... +60 °C
Dimensions	100 (l) × 7.5 (∅) mm
Material	Stainless steel, AISI 316
Environmental	Watertight from 0.1 to 4 bar
Cable Extension	PUR black, 5 × 0.5 mm^2 Cu, 5 m 10 meter shielded cable with male-female connectors
Ingress protection	IP68 (connector)

Table 56 QMT107 Soil Temperature Probe Specifications

Property	Description/Value
Measurement range	-40 ... +60 °C
Output signal	Four-wire connection
Temperature sensor	7 × Pt-100 IEC 751 1/3 Class B
Temperature reference	100R00 0.01% 5 ppm resistor
Accuracy, when zero-point calibration has been activated	±0.3 °C
Operating temperature range	-40 ... +60 °C
Storage temperature range	-40 ... +80 °C
Supply voltage VCC	6 ... 30 VDC
Settling time	<10 ms
Power consumption	<1.5 mA
Output load	>1 MΩ (to ground)
Weight (gross/net)	875 g / 640 g
Cable length	1 m
Housing material	Glass fiber tube/epoxy fill
Housing classification (electronics)	IP 68 (NEMA 4)
Dimensions	1200 (h) × 20 (∅) mm

Soil Moisture Sensor

Table 57 ML2x Soil Moisture Sensor Specifications

Property	Description/Value
Full Range	0 ... 1.0 $m^3.m^{-3}$
Accuracy	± 0.02 $m^3.m^{-3}$ after calibration to a specific soil type, or, ± 0.05 $m^3.m^{-3}$ using the supplied soil calibration, in all 'normal' soils, over range 0.05 to 0.6 $m^3.m^{-3}$ and 0 to 40 °C ambient temperature.
Soil conductivity range	Accuracy figures apply over a soil conductivity range of 0 to 100 $mS.m^{-1}$. Calibratable up to 2000 $mS.m^{-1}$.
Soil sampling volume	90% influence within cylinder of 2.5 cm diam., 6 cm long, (approx 30 cm^3), surrounding central rod.
Environment	Can be buried to wide ranging soil types or water for long periods without malfunction or corrosion.
Stabilization time	1 to 5 sec. from power-up, depending on accuracy required.
Response time	Less than 0.5 sec. to 99% of change
Duty cycle	100 % (continuous operation possible)
Input requirements	5 ... 15 VDC unregulated
Current consumption	19 mA typical, 23 mA max.
Output signal	Approx. 0 ... 1 VDC for 0 ... 0.5 $m^3.m^{-3}$
Dimensions	Measuring rods 60 mm, overall length 207 mm including pins (see Figure 130 below).
Extension Tubes (optional)	For convenient placement and removal when burying. Choice of 50 cm or 100 cm (can be joined).
Case material	PVC
Rod material	Stainless steel
Cable length	Standard 5m (maximum length 100m)
Weight	350 g (with 5m cable)

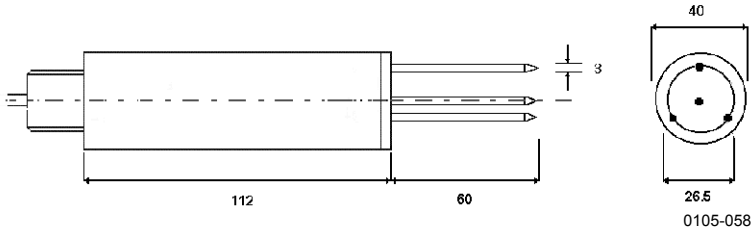


Figure 130 Soil Moisture Sensor Dimensions

Water Level Sensors

Table 58 QMV101 Water Level Sensor Specifications

Property	Description/Value
Measuring range	1.5 to 600 m
Performance (accuracy)	± 0.25 % of F.S. (BSL) [1)]
Output signal	4 ... 20 mA
Overpressure	2 ... 6 × F.S. (scale dependent)
Operating temperature	-20 ... +60 °C
Compensated temperature range	-2 ... +30 °C
Housing	316 stainless steel
Weight	0.2 kg
Vented cable	6-core polyurethane cable with kevlar strain relieving cord
Cable length	To be specified in the order
Included	Junction box with dessicator can, cable clamp

1) Static accuracy includes the combined errors due to nonlinearity, hysteresis, and nonrepeatability on a Best Fit Straight Line (BFSL) basis at 25° C per ISA S51.1.

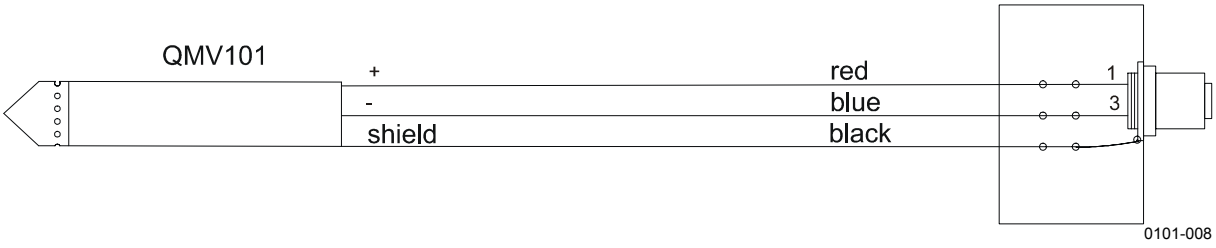


Figure 131 Wiring of QMV101 Water Level Sensor

Table 59 QMV102 Water Level Sensor Specifications

Property	Description/Value
Measuring range	0.75 to 600 m
Performance (accuracy)	±0.1 % of F.S. (BSL) [1)]
Output signal	4 ... 20 mA, 2-wire
Overpressure	4 ... 8 × F.S. (scale dependent)
Operating temperature	-20 ... +60 °C
Compensated temperature range	-2 ... +30 °C
Housing	Fully welded titanium construction
Weight	0.2 kg
Vented cable	6-core polyurethane cable with Kevlar strain relieving cord
Cable length	To be specified in the order
Included	Junction box with dessicator can, cable clamp

1) Static accuracy includes the combined errors due to nonlinearity, hysteresis, and nonrepeatability on a Best Fit Straight Line (BFSL) basis at 25° C per ISA S51.1.

Leaf Wetness Sensor

Table 60 QLW101 Leaf Wetness Sensor Specifications

Property	Description/Value
Sensor Type	Artificial leaf electrical resistance
Excitation	Bipolar (5V nominal) built-in
Time Constant [1]	2 seconds
Current Output	Variable resistance:>1MOhm (dry) to <130KOhm (wet)
Supply Voltage	1mA (typical) at +5 VDC ±10%
Sensor Area	28 cm^2
Attached Cable Length	5 m
Cable Type	2-twisted pair, 24 AWG shielded cable with UV-resistant jacket, wires stripped and tinned
Recommended Max Cable Length [1] 24 AWG Cable (3-conductor) 22 AWG 2-Twisted Pair Cable 18 AWG Cable (3-conductor)	 91 m 194 m 218 m
Substrate material Grid material Mounting Bracket	Glass-reinforced, ceramic-filled laminate 1 oz. copper, nickel, and 50 µin gold plate White powder-coated aluminum
Dimensions (H x W x T)	51 mm x 38 mm x 6 mm
Weight	227 g

1) Increasing the cable length above the recommended maximum cable length causes measurement error in the form of lower moisture readings.

Fuel Moisture Sensor

Table 61 QFM101 Fuel Moisture Sensor Specifications

Property	Description/Value
Fuel moisture sensing element	Dry ponderosa pine dowel with imbedded wire electrodes
Fuel moisture measurement principal	Capacitance of wood calibrated to read percentage of moisture by weight.
Fuel moisture measurement accuracy	0 ... 12 %FM [1]: ±1.9 %FM RMSE [2] (two-week period) 12 ... 30 %FM: ±3.6 %FM RMSE >30 %FM: ±16 %FM RMSE
Temperature sensor	Single thermistor
Conversion table range	-50 °C ... +50 °C
Temperature measurement accuracy	±0.2°C, from -20 °C to +80 °C
Size	Base diameter 28.6 mm Over-all length 305 mm
Weight	125 g

1) %FM = measured fuel moisture units
2) RMSE = Root Mean Square Error

Communication Devices

Table 62 SATELLINE 3AS Radio Modem Specifications

Property	Description/Value
Transceiver:	
Frequency range	380 ... 470 MHz
Channel spacing	12.5 / 25 kHz
Number of channels	160 / 80
Frequency stability	< ± 1.5 kHz
Type of emission	F1D
Communication mode	Half-duplex
Transmitter:	
Carrier power	10 mW ... 1 W / 50 ohm
Carrier power stability	+2 dB / -3 dB
Adjacent channel power	acc. to EN 300 220-1 / ETS 300 113
Spurious radiations	acc. to EN 300 220-1 / ETS 300 113
Receiver	
Sensitivity	-116 ... -110 dBm (BER < 10 E-3)
Co-channel rejection	> -12 dB
Adjacent channel selectivity	> 60 dB /> 70 dB
Intermodulation attenuation	> 65 dB
Spurious radiations	< 2 nW
Data modem:	
Interface	RS-232 or RS-422, RS-485
Interface connector	D 15, female
Data speed of RS interface	300 - 38400 bps
Data speed of radio interface	19200 bps (25 kHz channel) 9600 bps (12,5 kHz channel)
Data formats	Asynchronous data
General:	
Operating voltage	+9 ... + 30 VDC
Power consumption	1.8 VA typical (receive) 6.0 VA typical (transmit) 0.05 VA typical (when DTR is "0")
Temperature range	-25°C ... +55°C
Antenna connector	TNC, 50 ohm, female
Construction	Aluminium enclosure
Size H x W x D	137 x 67 x 29 mm
Installation plate	130 x 63 x 1 mm
Weight	250 g

Block Diagrams

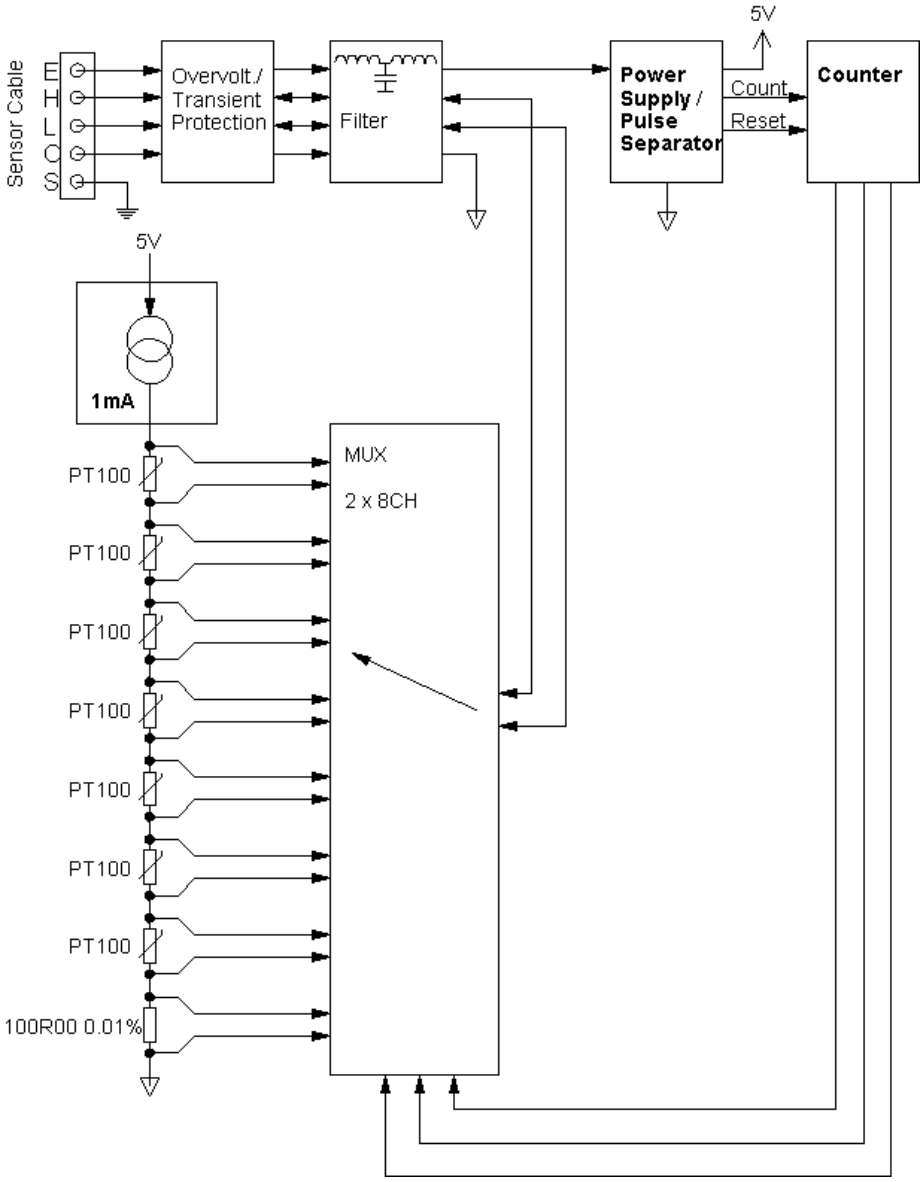


Figure 132 QMT107 Soil Temperature Probe Block Diagram

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APPENDIX A
GLOSSARY

This glossary includes:

- Explanations of some general meteorological terms
- Explanations of some general technical terms
- Descriptions of MAWS components and concepts
- Explanations of the terms used in MAWS specifications.

Accuracy The degree of conformity of a measured or calculated value to its actual or specified value.

Altitude The station altitude in meters from sea level.

Atmospheric pressure The pressure at a given point due to the gravitational force on the column of air above it. The official unit of pressure is Pascal (Pa = newton/m^2). The unit hectopascal (hPa) has been chosen to be used in meteorological barometric pressure measurement.
1 hPa = 100 Pa = 1 mbar

Barometer Instrument for measuring atmospheric pressure.

Barometric pressure See Atmospheric pressure.

Baud The unit of signaling speed of a line, which is the number of transitions (voltage or frequency changes) that are made per second. The term has often been erroneously used to specify bits per second. However, only at very low speeds is baud equal to bps; for example, 300 baud is the same as 300 bps. Beyond that, one baud can be made to represent more than one bit. For example, a V.22bis modem generates 1200 bps at 600 baud.

Celsius scale Temperature scale having the freezing point of pure water at 0 °C and the boiling point at 100 °C under standard sea level pressure. All the temperatures measured with MAWS are given in Celsius degrees.

Configuration Set of instructions for the MAWS logger. The compiled configuration (a script) is in fact a program that runs in MAWS.

Crosswind The wind blowing perpendicular to the course of a moving object.

Damping ratio Describes the response of a wind vane to a sudden change in wind direction. It is defined as the ratio of the actual damping to the critical damping. Critical damping is that value of damping which gives the fastest transient response without overshoot.

Delay distance The passage of air necessary over a wind vane to cause the vane to respond to 50 % of a step function change in wind direction.

Dew point (temperature)

The temperature at which the air, if cooled, would reach saturation, and at which dew would therefore begin to condense out on a solid surface. The TD is calculated using the following formula:

$$TD = \frac{c \times b}{c \times \frac{a}{2} + b} - 273.15$$

where

$a = \ln\frac{100}{RH}$
$b = 15.0 \times a - 2.1 \times TA + 2711.5$
$c = TA + 273.15$
TA = Actual air temperature [°C] measured by MAWS
RH = Actual relative humidity [%] measured by MAWS

DSI485A Serial RS-485 communication module for MAWS.

DSU232 Serial RS-232 communication module for MAWS.

Global radiation The total of direct solar radiation and diffuse sky radiation received by a horizontal surface. Global radiation is measured by pyranometers.

Gust The peak momentary wind velocity within a given interval of time, for example, 10 minutes. $(V_{max}-V_{min})/V_{mean}$.

Hexadecimal Numbering system using the base number 16 and including the ten decimal digits (0 to 9) along with six alpha digits (A to F).

Humidity The water vapor content of the air. Weather station sensors commonly measure relative humidity. Relative humidity is the ratio of water vapor pressure present in a gas (P_w) to the maximum pressure of water vapor that could be present in the gas in that temperature [$P_{ws}(t)$].
%RH = 100 x P_w / P_{ws} (t)

LED Light Emitting Diode

Logger The processing unit of the MAWS weather station. The electronics of the logger take care of measuring, storing, and processing of the measured quantities.

Logging The process of storing the measured and calculated values in the logger's memory.

Lull The minimum of wind speed during a certain time interval (as defined in the wind calculation module of MAWS).

Modem A device that allows a terminal or computer at one location to communicate with a terminal or computer at a distant location via wire or telephone lines.

Precipitation Term that refers to all forms of water particles that fall upon the earth. This includes rain, snow, and hail. It is the universal practice to distinguish between rain, snow, and total precipitation. Snow is sometimes measured as such and sometimes it is melted and measured as water.

Pslevel The pressure sensor level in meters from the station altitude.

Pyranometer An instrument that measures solar energy received from the entire hemisphere (180 degrees field of view). The output is expressed in Watts per square meter (W/m^2).

QFE The actual atmospheric pressure at the level of station altitude or at the height of the runway threshold. The difference of the pressure sensor level and the station altitude (or runway threshold) is indicated by the pressure sensor (pslevel) setting in MAWS. QFE is normally used for aviation purposes. QFE is calculated using the following formula:

$$QFE = PA \cdot e^{\frac{HS}{7996 + b \cdot HS + 29.33 \cdot TA}}$$

where

PA = Station pressure measured by MAWS [hPa]
HS = The height of the pressure sensor from the station level or from the runway threshold level [m], set by the **pslevel** command
b = 0.0086 °C/m
TA = Actual air temperature [°C] measured by MAWS

QFF

The sea level pressure as QNH, but the value is corrected by the actual air temperature (or in some cases by virtual temperature, that is, temperature 12 hours ago). QFF is used in synoptical observations. QFF is calculated using the following formula:

$$QFF = QFE \cdot e^{\frac{HR}{7996 + b \cdot HR + 29.33 \cdot TA}}$$

where

b = 0.0086 °C/m
HR = Station altitude [m], set by the **altitude** command
TA = Actual air temperature [°C] measured by MAWS

QMH102

The humidity and temperature probe for MAWS. Temperature is measured with a Pt-100 and humidity with HUMICAP® 180 sensor.

QML102

The logger of MAWS.

QNH (altimeter setting)

The atmospheric pressure at sea level in the standard atmosphere. The station altitude is indicated by station altitude setting in MAWS (difference of mean sea level and station altitude). QNH is used for aviation purposes. QNH is calculated using the following formula:

$$QNH = QFE \cdot e^{\frac{0.03416 \cdot HR \cdot (1 - d)}{288.2 + c \cdot HR}}$$

where

HR = Station altitude [m], set by the **altitude** command.
d = $0.19025 \cdot \ln \frac{QFE}{1013.2315}$
c = 0.00325 °C/m

Rain gauge

Measures precipitation based on depth, that is, the depth to which a flat surface would be covered if no water were lost by run-off or evaporation.

RS-232

Standard serial transmission protocol. A standard interface between a computer input/output port and a peripheral device.

RS-485

Standard serial transmission protocol. This protocol permits multi-drop networks (up to 32 nodes) using a single twisted pair cable.

Solar radiation The solar energy received from the entire hemisphere. It is measured with a pyranometer.

Synchronizing time Ties the operation to the clock for software operations. For instance, if an operation is always to be performed twenty minutes to the hour, the synchronizing time should be set to 00:40:00.

WMO The World Meteorological Organization.

ZModem File transfer protocol that is used when transferring files between MAWS and a terminal program.